TWELFTH ANNUAL REPORT

OF THE

OHIO AGRICULTURAL

EXPERIMENT STATION,

FOR 1893.

PRINTED BY ORDER OF THE STATE LEGISLATURE.

TABLE OF CONTENTS.

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

SETH H. ELLIS	Springboro.
HON. JOSEPH H. BRIGHAM	Delta.
R. H. WARDER	North Bend.
THE GOVERNOR OF THE STATE, THE DIRECTOR OF THE STATION,	*Ex-Officio.*

OFFICERS OF THE BOARD.

SETH H. ELLIS	President.
R. H. WARDER	Secretary.
BERTHA E. WILDMAN	Treasurer.

STATION STAFF.

CHARLES E. THORNE	Director.
WILLIAM J. GREEN	Horticulturist and Vice-Director.
J. FREMONT HICKMAN, M. A. S	Agriculturist.
FRANCIS M. WEBSTER	Entomologist.
BERTHA E. WILDMAN	Bursar.
EDWIN C. GREEN	Assistant Horticulturist.
F. J. FALKENBACH	Chemist and Meteorologist.
J. S. HINE, B. SC	Superintendent N. W. Sub-Station.

PUBLICATIONS.

The bulletins of this Station are issued at irregular intervals. They are not republished in the annual report, but are consecutively paged and a complete index for the year's issues is published in the annual report, which constitutes the final issue for each year. Persons who preserve their bulletins may have them bound in cloth, by returning them to the Station with thirty cents per volume for binding and postage.

Announcement.

The Ohio Agricultural Experiment Station is organized under an act of the General Assembly of Ohio, passed April 17th, 1882, and supplemented by an act of Congress approved March 2, 1887.

The Station is prepared to test new varieties of grains, fruits and garden vegetables; to examine seeds that are suspected of being unsound or adulterated; to identify and name grasses, weeds and other plants; to identify insects and suggest measures for the control of such as are injurious, and to give advice concerning the prevention of the fungoid diseases which affect vegetation.

The Station is not prepared to furnish analyses of chemical or commercial fertilizers, as in Ohio that work is performed under direction of the Secretary of the State Board of Agriculture at Columbus; but the Station will at all times respond to requests for advice concerning the use of such fertilizers.

The Station is not prepared to examine foods and dairy products suspected of adulteration, as that work is provided for in the Ohio Dairy and Food Commission, whose headquarters are at Columbus.

The Station is not at present prepared to offer advice or treatment for contagious animal diseases, but would refer all seeking such assistance to the Ohio Live Stock Commission, at Columbus.

Any citizen of Ohio has the right to apply to the Station for any information it can give, and all such applications will receive prompt attention.

Visitors to the Station are always welcome.

Address all communications to

EXPERIMENT STATION, *Wooster, Ohio.*

Twelfth Annual Report.

REPORT OF THE BOARD OF CONTROL.

To Hon. WILLIAM MCKINLEY, *Governor of Ohio:*

SIR: The Board of Control of the Ohio Agricultural Experiment Station submits herewith its annual report for the year ending December 31, 1893.

The work of the Station has gone on quietly and effectively as usual and with great advantage to the State at large.

The bulletins published have been of the same high order of useful knowledge, which has hitherto distinguished the Ohio reports.

The able and faithful work accomplished continues to reflect great credit on the State and to maintain the high rank of the Ohio Station among those of other states.

The bulletins on sub-irrigation and insect destruction and fungicides are of very great value, and worth to the State at large many times the cost of the Station.

IMPROVEMENTS.

In our last annual report it was stated that a portion of the funds donated by Wayne county to secure the location of the Station had been held in the State Treasury in consequence of a doubt on the part of the Auditor of State, arising from the adverse decision of the Supreme Court respecting the constitutionality of the law under which the Station had been moved to Wayne county. By a special resolution passed March 1st, the General Assembly directed the State Auditor and Treasurer to honor the requisitions of the Board of Control on this fund, and under the advice of the Attorney General the funds were released and are being expended by the Station in the improvement of the Station farm.

These improvements include the completion of the greenhouses and insectary, plans of which were given in the last report; the construction of about 26 miles of tile drain; the inclosing of the farm with a substantial fence; the remodeling of one of the barns on the farm and the purchase of three small tracts of land adjoining the farm, which were needed to provide convenient access to the main buildings and for residence purposes.

SPECIAL APPROPRIATIONS.

On account of the unsettled condition of affairs resulting from the obstructive litigation referred to in our last report, and by advice of members of the finance committee of the General Assembly, the request for appropriations for permanent improvements made in that report was withdrawn, and the following items were substituted, and were granted in full:

Sub-station for field experiments	$1,000 00
Live stock	4,350 00
Implements and farm machinery	1,794 00
Supplies	456 00
Special work in entomology	400 00
Fees of architect (on plans for main building)	1,000 00
Expenses of Board of Control (including deficiency)	715 93
Total	$9,715 93

The first item has been expended in the preparation for experiment of the tract in Fulton county, described in our last report. It is expected that most of this land will be placed under experimental cropping during the coming season.

Of the second item, a part has been expended in the purchase of stock cattle, but the major portion is being held with the view of purchasing small herds of pure bred cattle and sheep, representing the principal breeds found in the State. It is hoped that the various associations of breeders will assist in the selection of these cattle, and therefore the purchase has been delayed until they should have opportunity to take action.

The third and fourth items are being expended in the equipment of the farm and gardens with implements and machinery, including harness and similar supplies.

The fifth item is being expended in the field study of outbreaks of injurious insects as they occur in various parts of the State, full details of which will be found in the report of the Station Entomologist.

THE PRESENT STATUS.

The Court of Common Pleas has held that the law of estoppel applies to all who voted in favor of levying a tax on the county to secure the location of the Station, and this tax is now being regularly collected and the interest on the bonds issued in anticipation of the tax is being paid. With these facts in view there can no longer be any question as to the permanency of the Station's location in Wayne county. The county is faithfully fulfilling its part of the contract with the State, and as a very large portion of the work of the Station is of equal value to all the farmers of the State it is but simple justice that the State should complete the Station's equipment.

FURTHER EQUIPMENT NEEDED.

The Station as yet possesses no building for its general work, the plans for such a building having been temporarily laid aside for reasons given in our last report. It is at present occupying for this purpose the upper floors of a business block in town, situated a mile from the farm and altogether insufficient for the work required. The Station's valuable books and museum collections, many of which cannot be duplicated, are exposed to loss by fire, and its officers are necessarily so scattered and their work so divided that it cannot be carried on except at a great waste of time and energy.

Next to the need of a building for general administration is that of barns, dairy house, tool house, etc., and a residence for the director, this being required because of the impossibility of renting a sufficient number of dwellings near the farm.

The Board of Control therefore requests the appropriation by the General Assembly of $76,000, to be expended as per the following items:

Administration building	$50,000 00
Three barns and power house	17,000 00
Dairy house and equipments	3,000 00
Tool house	1,000 00
Director's residence	4,000 00
Sub-station for field experiments	500 00
Expenses of Board of Control	500 00

THE STATION AND THE STATE UNIVERSITY.

The State University and the Experiment Station have never had any organic connection, being governed by separate administrative boards. The Station, however, had occupied the farm belonging to the University, and had made thereon certain improvements. For these the University has paid the Station the sum of $5,000, which sum does not

appear in the financial statement of this year because it was not received until after the close of the fiscal year which this statement covers.

By mutual agreement, the field tests of fertilizers begun by the Station in 1888 on the University farm, are continued, through the co-operation of the agricultural departments of the two institutions.

PERSONNEL.

No change has been made in the personnel of the Station during the year, Mr. Ellis having been re-appointed as member of the Board of Control at the expiration of his term of office in the spring.

Respectfully submitted,

R. H. WARDER,
Secretary State Board of Control.

REPORT OF THE TREASURER.

To Hon. S. H. ELLIS, *President Board of Control:*

SIR: I have the honor to submit herewith a report of the receipts and expenditures of this Station for the fiscal year ending June 30, 1893.

In statement A will be found a record of the disbursements from the annual appropriation received from the United States treasury.

STATEMENT A.

THE OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES TREASURY.

Dr.

1893.

To receipts from treasurer of the United States, as per appropriation for the year ending June 30, 1893, under act of Congress approved March 2, 1887 .... $15,000 00

Cr.

June 30, by salaries	$9,680 00	
" labor	1,693 20	
" supplies	1,044 88	
" freight and expressage	8 35	
" tools and implements	364 95	
" live stock	125 00	
" fencing and drainage materials	2 91	
" furniture and general fittings	496 00	
" technical apparatus and supplies	249 57	
" library	80 90	
" printing, postage and stationery	837 05	
" travel and incidentals	393 13	
" building repairs	24 06	
Total		$15,000 00

I, the undersigned, duly appointed auditor for the corporation, do hereby certify that I have examined the books and accounts of the Ohio Agricultural Experiment Station for the fiscal year ending June 30, 1893; that I have found the same well kept and correctly classified as above, and that the receipts for the time named are shown to have been $15,000.00, and the corresponding disbursement $15,000.00, for all of which proper vouchers are on file, and have been by me examined and found correct.

S. H. ELLIS,
Auditor Board of Control.

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the institution named.

BERTHA E. WILDMAN,
Treasurer Board of Control.

The receipts and expenditures from farm produce and other items are shown in statement B:

STATEMENT B.

OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH PRODUCE FUND.

TO RECEIPTS.

Dr.

1893.		
June 30, from sales of live stock	$1,510 00	
" " milk	240 98	
" " agricultural produce	3,642 41	
" " horticultural produce	975 97	
" labor	1,195 95	
" rent	151 75	
" miscellaneous sales	825 65	
Total receipts		$8,542 71
To balance brought forward July 1, 1892		9 85
Total		$8,552 56

BY EXPENDITURES.

Cr.

1893.		
June 30, for labor	$2,761 33	
" supplies	1,808 69	
" freight and expressage	416 77	
" tools and implements	358 05	
" live stock	2,063 59	
" furniture and general fittings	65 80	
" technical apparatus	85	
" printing, postage and stationery	31 83	
" travel and incidentals	45 12	
" interest	959 02	
" building repairs (material and labor)	30 73	
Total expenditures		$8,541 78
By balance carried forward		10 78
Total		$8,552 56

Of the total amount of expenditures listed in the above statement the sum of $4,466.33 was the balance due on a debt incurred by the Station in 1887, for equipment bought of the Ohio State University at the time

of the re-organization of the Station under the Hatch act. The amount of this balance is divided among the several items as follows:

Supplies	$1,134 10
Live stock	2,063 59
Implements	316 62
Interest	952 02
	$4,466 33

Of the total amount of income shown in statement B, the sum of $4,024.55 was received for live stock, produce, implements and office equipment sold at the time of the removal of the Station to Wooster.

The receipts from labor include $1,176.02, received for work done for the Ohio State University, such as teaming, mowing campus, etc., the account extending over two years previous to the removal of the Station.

Statement C is a statement of our account with the State Treasury.

STATEMENT C.

STATEMENT OF ACCOUNT OF THE OHIO AGRICULTURAL EXPERIMENT STATION WITH THE STATE TREASURY.

Date of appropriation.	Appropriation for—	Total amount to the Station's credit.	Total amount expended.	Bal. in treasury June 30, 1893.
1893	Sub-station for field experiments	$1,000 00	$192 38	$807 62
	Live stock	4,350 00	1,090 16	3,259 84
	Implements and farm machinery	1,794 00	339 85	1,454 15
	Supplies	456 00	34 60	421 40
	Special work in entomology	400 00	57 30	342 70
	Fees of architect [1]	1,000 00	1,000 00	....
	Expenses of Board of Control	715 93	368 15	347 78
	Totals for 1893	$9,715 93	$3,082 44	$6,633 49
	Balance of appropriations for 1891 and 1892 brought forward July 1, 1892—			
1891	Fire-proof safe, office furniture and museum cases	432 75	432 75	....
	Sub-station for field experiments with fertilizers	1,000 00	337 87	[2][662 13]
	Illustrating bulletin	381 40	114 04	[2][267 36]
1892	Spraying experiments	500 00	420 27	79 73
	Expenses of Board of Control	94 14	94 14	....
	Totals	$12,124 22	$4,481 51	$6,713 22

(1) For plans for administration building.

(2) Owing to some change of plans and the necessary interruption and delay of work incident to the removal of the Station to its new home, these balances remained unused at the expiration of the time, during which they were available, and they therefore lapsed into the State treasury, Feb. 15, 1893. As they have ceased to be available they are not included in the total balance.

Statement D is a statement of account with the donation received from Wayne county:

STATEMENT D.

Ohio Agricultural Experiment Station in Account with Donation from Wayne County.

RECEIPTS.

Unexpended balance brought forward July 1, 1892		$26,371 85

EXPENDITURES.

1893.		
June 30, for land	$2,900 00	
" buildings and repairs of buildings	14,533 87	
" fencing	942 97	
" drainage	2,867 66	
" fruit and forest tree planting	385 16	
" interest on building contract	[3]361 70	
Total expenditures		$21,991 36
By balance carried forward		4,380 49
Total		$26,371 85

(3) On account of the pending litigation over the constitutionality of the law under which the Station was located in Wayne county, the State Auditor refused to honor the requisitions of the Board on the Wayne county donation, until authorized to do so by a special act of the legislature; by the time this act was passed, the above amount of interest had accrued on the contract for buildings.

The foregoing statements are all included in the following Statement E, which shows the total receipts and expenditures for the fiscal year :

STATEMENT E.

Total Receipts and Expenditures of the Ohio Agricultural Experiment Station for the Year Ending June 30, 1893.

RECEIPTS.

From U. S. treasury	$15,000 00	
" farm produce, etc	8,542 71	
" State appropriations for 1893	9,715 93	
Total receipts for the year		$33,258 64
Total balance brought forward July 1, 1892		28,789 99
Total		$62,048 63

EXPENDITURES.

For salaries	$9,680 00	
" labor	4,628 88	
" supplies	3,016 18	
" freight and expressage	425 12	
" tools and implements	1,078 85	
" live stock	3,278 75	
" fencing and drainage	3,813 54	
" furniture and general fittings	994 55	
" technical apparatus and supplies	250 42	
" library	80 90	
" printing, postage and stationery	982 92	
" travel and incidentals	540 16	
" buildings and repairs of buildings	14,588 66	
" land	2,900 00	
" fruit and forest tree planting	385 16	
" sub-station for field experiments	530 25	
" special work in entomology	57 30	
" fees of architect	1,000 00	
" expenses of Board of Control	462 29	
" interest	1,320 72	
Total expenditures for the year		$50,014 65
By balances lapsed		(4) 929 49
By total balance carried forward		11,104 49
Total		$62,048 63

(4) See foot-note page XIII.

LAND AND IMPROVEMENTS.

During the fiscal year, the following amounts have been expended for additions to the farm and for permanent improvements on the farm:

Land	$2,900 00
Buildings and repairs of buildings	15,944 46
Fencing and drainage	3,810 63
Fruit and forest tree planting	385 16
Total	$23,040 25

BERTHA E. WILDMAN, *Treasurer.*

REPORT OF THE DIRECTOR.

To HON. S. H. ELLIS, *President of the Board of Control:*

SIR: I have the honor of submitting herewith the twelfth annual report of the officers of the Ohio Agricultural Experiment Station:

THE SEASON.

During the months of April and May there were thirty-four rainy days, with a total precipitation at the Station of nearly twelve inches, which is about fifty per cent. above the eleven-year average for this section; but with June a drouth began which continued until October, the total precipitation for June, July, August and September being but sixty per cent. of the average rainfall. The result was that while the wheat and hay crops were better than the average, the yields of corn and oats were greatly reduced, corn especially being almost a total failure except on low lands.

THE STATION'S WORK AND PLANS.

The time and energy of the Station's staff have been so largely occupied in the work necessary to the proper equipment of the new farm that the regular work of the Station has suffered materially. The field experiments with fertilizers, hitherto conducted on the farm at Columbus, have been continued, through the coöperation of Prof. Thos. F. Hunt, Professor of Agriculture and Farm Superintendent, and Mr. F. P. Stump, Farm Foreman, of the State University. It is hoped that these experiments may be continued indefinitely. A similar, but more extensive series is being inaugurated on the Wayne county farm, and a few of the most important features of the work will be repeated on the farm in Fulton county, thus bringing under observation three characteristic soils of the State. It is greatly to be desired that this work should be extended so as to include at least the clays of the Western Reserve and of the great limestone region of the southwestern part of the State.

The experiments with varieties of cereals which have been a leading feature of the work of this Station since its first foundation are

fully inaugurated on the new farm, and on a more comprehensive and systematic plan than it has heretofore been possible to carry out.

Almost thirty acres of land have been prepared for field experiments with fertilizers; about fifty acres for variety testing of cereals, and about twenty acres for cultural work with cereals, making in all one hundred acres, all of which has been drained with tile drains laid thirty-six feet apart and thirty inches deep. In addition to this, considerable partial draining has been done, a total of twenty-six miles of tile drain having been laid during the summer.

The Station now possesses a much larger area of land suitable for grazing than it has heretofore had access to, and it is hoped that the live stock industry may hereafter be given the attention which its importance merits. Plans are being made for comprehensive experiments in dairying, cattle feeding and sheep husbandry, and it is hoped that by another year investigations may be in progress in all these lines.

About fifteen acres of land have been planted in fruits, and a considerable additional area will be devoted to the culture of potatoes and garden vegetables. These, in addition to the excellent greenhouse equipment now in operation, will put the Horticultural Department of the Station on a far better footing than it has ever before enjoyed.

The removal of the Station has caused less interruption to its entomological studies than to other lines of work. The new insectary, though small, is compact and well equipped, and a considerable amount of work has been done in various parts of the State.

The report of the Chemist will show that he has accomplished a considerable amount of chemical work, in addition to his duties as Meteorologist. It is hoped that this work in the future may add materially to our knowledge of the chemistry of Ohio soils and feeding stuffs.

FARMERS' INSTITUTES.

Under the able management of Secretary L. N. Bonham, of the State Board of Agriculture, the work of the farmers' institute is year by year increasing in interest and value. During the institute season one or more members of the Station staff have been constantly engaged in this work, and we feel that it is an effective medium through which the Station's work may be made useful to the farmers of the State.

LOCAL INTEREST.

The farmers of Wayne county are manifesting a lively interest in the Station's work. On several occasions they have been invited to visit the Station to inspect certain features of the work, to which they have responded in large numbers. While it must necessarily require

several years to get the farm into such condition that a visit to it can be of much service to the practical farmer, yet the work already done is sufficient to show that by the application to this work of the methods of husbandry followed by the excellent farmers of this region it may be made to yield results of very great practical value.

PUBLICATIONS.

The time of the executive officers of the Station has been so closely occupied during the year by the details of business that it was impossible to keep up to date in the publication of results, and only six bulletins have been issued since our last report. These are:

BULLETIN 48 (VOL. VI, NO. 1), FEBRUARY, 1893, BY W. J. GREEN.

Profit in spraying orchards and vineyards; containing formulæ for spraying mixtures, with practical directions for their application.

SUMMARY.

(1.) The profit to be derived from spraying orchards often exceeds $20 per acre, and for vineyards is much more. The fruit crop of the State would be enhanced in value by several million dollars annually if the practice were generally followed.

(2.) Combined fungicides and insecticides are recommended whenever applicable, because of a saving of time; a less liability of injuring foliage; greater efficiency in some cases, and as a precautionary measure in others.

(3.) Dilute Bordeaux mixture, copper-arsenic solution and ammoniacal solution of copper carbonate are the most useful for the treatment of the diseases herein mentioned and the first has the widest range of usefulness of all.

(4.) Early spraying is the key to success in the use of fungicides.

(5.) For the plum curculio and shot-hole fungus use Bordeaux mixture and Paris green combined, making three or four applications.

It is not known that this treatment will prevent the black knot, but cutting away and burning the diseased branches will accomplish the result.

(6.) Scabby apples rot much earlier than those free from scab, and spraying with fungicides will save at least 50 per cent. of this loss.

(7.) Spraying with fungicides in the season of 1892 prevented much of the early dropping of apples, which is usually attributed to wet weather.

(8.) For apples, two applications of Bordeaux mixture before blooming are advised, and two of the same mixture after blooming, with Paris green added.

(9.) The same treatment is recommended for the pear as for the apple, before blooming, but the copper-arsenic solution is advised after blooming.

(10.) The Bordeaux mixture, if used too late, causes a russet appearance on both pears and apples.

(11.) The quince may be treated the same as apples, or with Bordeaux mixture alone.

(12.) The treatment advised for the cherry consists in making two or three applications of Paris green, two ounces to fifty gallons of water.

(13.) Peach trees and American varieties of plums have very tender foliage, and must be treated with very weak mixtures, if at all.

(14.) Raspberries may be treated with Bordeaux mixture alone; grapes with the same until the fruit sets, after which use copper carbonate. Potatoes should be sprayed at least five times with Bordeaux mixture and Paris green.

BULLETIN NO. 3, VOL. I, TECHNICAL SERIES, APRIL, 1893.

Entomological and Botanical papers: This bulletin contains a number of technical, entomological and botanical papers published by coöperation of the Station with the Ohio Academy of Science. The titles of the papers are given on page XXIII.

BULLETIN 49 (VOL. VI, NO. 2), MAY, 1893, BY C. E. THORNE AND J. F. HICKMAN.

Field experiments with commercial fertilizers, including: Experiments on wheat at the Station, coöperative experiments on wheat, experiments on crops grown in rotation, experiments on oats at the Station, experiments on corn at the Station and coöperative experiments on corn.

SUMMARY.

The experiments of this Station with fertilizers now include four years' continuous culture of wheat on the same land, with and without fertilizers, on the farm hitherto occupied by the Station in Columbus and belonging to the State University; three years' similar culture of wheat in Columbiana county; four years' continuous culture of oats on the Columbus farm; five years' continuous culture of corn on the Columbus farm and in Columbiana county, and fourteen coöperative experiments, made in 1889, 1890, 1891 and 1892 by farmers in Ashtabula, Holmes, Miami, Huron, Licking, Butler and Washington counties, besides several years' study of crops grown in rotation and of plants grown in boxes.

These experiments must be continued further before positive conclusions can be drawn, but at the present date the following tentative conclusions seem to be justified:

(1.) The use of superphosphate and potash, separately or in combination, but without nitrogen, has frequently caused a loss of grain in crops of corn and wheat on soils deficient in vegetable matter.

(2.) The yield of straw or stalks has almost invariably been increased by the use of superphosphate.

(3.) The use of superphosphate has frequently, and that of potash has occasionally been followed by a considerable increase of crop, both of grain and straw or stalks, on sod ground or land containing an abundance of decomposing vegetable matter.

(4.) An increase of grain in the crop has generally followed the use of nitrate of soda, and this has happened in almost every case when the nitrate has been used in combination with superphosphate or potash.

(5.) When a complete fertilizer has been used, containing both phosphoric acid and potash, in combination with nitrogen, the phosphoric acid being carried in less active forms than bone-black superphosphate, an increase of crop has resulted in practically every case; but at present prices of fertilizers and grain respectively, this increase has invariably cost more than its value in the market.

(6.) While, therefore, these experiments demonstrate the possibility of producing a regular and certain increase in the yield of cereal crops by the use of a complete chemical fertilizer, yet they show that if such fertilizers are to be used with any prospect of profit in Ohio in the production of cereal crops and as

a part of a regular system of agriculture, that system must provide for the accumulation in the soil of the largest possible quantity of organic nitrogen, through the culture, in short rotations, of plants which have the power of obtaining nitrogen from sources inaccessible to the cereals.

BULLETIN 50 (VOL. VI, NO. 3), NOVEMBER, 1893; BY C. E. THORNE, J. F. HICKMAN AND F. J. FALKENBACH.

Experiments in feeding for milk, including a comparison of corn silage and field beets as food for milk production, a study of the comparative productive capacity of different cows, of the ratio between increase in live weight and production of butter fat, and suggestions as to possible improvements in milk production.

SUMMARY.

I. Our contrast of corn silage and field beets as food for milk production leads to the following conclusions:

1. The feeding of beets to milk cows has always increased the consumption of other foods and of total dry matter.

2. Beets have always produced an increase in the flow of milk and in the total yield of butter-fat, but this increase has never been sufficient to offset the additional consumption of food.

3. The cows have nearly always shown a greater average live weight while feeding on beets. A part of this increase was probably due to increased weight of the contents of the digestive tract, but a part seems to have been actual gain.

4. Beets have not diminished the amount of water drank, although fed in such quantity as to increase the watery contents of the food by 30 pounds per day.

5. Our experiments do not justify the assumption that the dry matter of beets is any more effective as a cattle food, pound for pound, than the dry matter of silage made from well matured corn containing 13 to 18 per cent. of grain.

6. In the region where the tests were made, and as the average of ten years' culture of corn and beets, side by side, two pounds of dry matter have been produced in the form of corn silage at a less cost than one pound of dry matter in the form of beets.

7. A question which our experiments suggest, but do not answer, is whether beets may be used with any greater advantage in comparatively small quantity and simply as appetizers.

8. While silage made from comparatively mature corn has shown the best results in general, our experiments suggest that silage should be made before the corn has reached full maturity.

II. The results of our study of the comparative productive capacity of different cows are as follows:

1. When fed a ration composed of about one-fifth to one-fourth grains and the remainder coarse foods of good quality, our cows and those of several other stations have produced an average of about $3\frac{1}{5}$ pounds of butter-fat to each hundred pounds of dry matter in the food, besides making a small gain in live weight.

2. In general, when this rate of production of butter-fat has been exceeded there has been a loss in live weight, and when the butter-fat has fallen below this rate there has been a gain in live weight.

3. Individual exceptions to this general rule show that while some cows may return a handsome profit on their food, others may be fed at an actual loss, even when both butter-fat and increase of live weight are counted at full value.

III. From a comparison of experiments made by several different stations we conclude that in the general average, full periods of fattening being compared with full periods of lactation, the increase in live weight from a given quantity of food seems to be about three times as great as the average yield of butter-fat from the same quantity of food; and that in the case of cows giving milk, increase in live weight may replace yield of butter-fat in the same general ratio, modified, however, by age, breed and advancement in lactation.

IV. The superior productiveness of individual cows in these tests and of the cows employed in the World's Fair test at Chicago demonstrates the possibility of achieving a great increase in average productiveness through intelligent selection and better feeding.

BULLETIN 51 (VOL. VI, NO. 4), DECEMBER, 1893, BY F. M. WEBSTER.

Descriptions of the Asparagus Beetle, the Western Corn Root Worm, the Broad Striped Flea-Beetle, the Blister Beetles, the Bag or Basket Worm, the Cabbage Aphis and the Apple Plant Louse, with chapters on "Some Insect Immigrants in Ohio," showing their lines of distribution, and "Insect Foes of American Cereals."

BULLETIN 52 (VOL. VI, NO. 5), DECEMBER, 1893, BY F. J. FALKENBACH.

Meteorological summary and index, included with the present report.

PAST PUBLICATIONS.

During the first six years of the existence of this Station (1882-88) its annual reports contained the full record of all its work. Of these annuals, the editions for 1882 and 1883 (First and Second reports) are exhausted, but there are still on hand a small number of the subsequent reports, which will be sent to any applicant on receipt of seven cents each for postage. The "first series" of the Station's bulletins, comprising those published prior to 1888, were chiefly issued in the form of newspaper slips. No file of them was preserved, and no copies can now be furnished.

The bulletins for 1888 comprise the first seven numbers of the "second series." They were published in small editions, and were fully incorporated in the annual report of that year. No copies of the bulletins can now be furnished, but there are still a few copies of the annual report.

Beginning with 1889, the bulletins have been published in complete form, and only abstracts have been republished in the annual reports. The supply of the first two issues for 1889 (the first treating on insects and insecticides, the second on the colic of horses) is exhausted, but a limited number of all issues since that date can be supplied.

Following are the titles of bulletins published separately from the annual reports:

No. 8 (Vol. II, No. 1), March, 1889.—Insects, insecticides and methods of collecting and studying insects.

No. 9 (Vol. II, No. 2), April and May, 1889—Colic of horses.

No. 10 (Vol. II, No. 3), June, 1889—Silos and ensilage. Silage and field beets as food for cows.

No. 11 (Vol. II, No. 4), July, 1889—Experiments with small fruits. Effect of early and late picking upon keeping quality of apples.

No. 12 (Vol. II, No. 5), August, 1889—Wheat: Cultural and variety tests.

No. 13 (Vol. II, No. 6), September, 1889—Insect remedies and prevention of potato rot.

No. 14 (Vol II, No. 7), November, 1889—Cabbage and cauliflower, and treatment of certain plant diseases.

No. 15 (Vol. II, No. 8), December, 1889—Annual report and meteorological summary.

No. 16 (Vol. III, No. 1), January, 1890—Experiments with potatoes.

No. 17 (Vol. III, No. 2), February, 1890—Field experiments with fertilizers.

No. 18 (Vol. III, No. 3), March, 1890—Experiments with corn and oats. Actinomycosis.

No. 19 (Vol. III, No. 4) April, 1890—Spraying to prevent insect injury. Insects affecting corn. Fungous diseases of plants. Collecting plants.

No. 20 (Vol. III, No. 5), June, 1890—Corn silage vs. sugar beets as food for milk production.

No. 21 (Vol. III, No. 6), July, 1890—Wheat: Cultural and variety tests.

No. 22 (Vol. III, No. 7), August, 1890—Strawberries and raspberries.

No. 23 (Vol. III, No. 8), September, 1890—The plum curculio, cucumber beetle, rhubarb curculio and clover stem borer. Potato blight.

No. 24 (Vol III, No. 9), October, 1890—Asparagus. Transplanting onions.

No. 25 (Vol. III, No. 10), November, 1890—Grape rot and corn smut.

No. 26 (Vol. III, No. 11), December, 1890—Annual report and meteorological summary.

No. 27 (Vol. IV, No. 1), January, 1891—Corn: Cultural, variety and fertilizer tests.

No. 28 (Vol. IV, No 2), February, 1891—Miscellaneous experiments in the control of injurious insects.

No. 29 (Vol. IV, No. 3), August 1, 1891—Fertilizers on wheat.

No. 30 (Vol. IV, No. 4), August 25, 1891—Wheat: Cultural and variety tests and treatment for smut.

No. 31 (Vol. IV, No. 5), September 1891—The wheat midge.

No. 32 (Vol. IV, No. 6), October, 1891—Experiments with small fruits. Diseases of the raspberry and blackberry.

No. 33 (Vol. IV, No. 7), November, 1891—The Hessian fly.

No. 34 (Vol. IV, No. 8), November, 1891—Forty years of wheat culture in Ohio.

No. 35 (Vol. IV, No. 9), December, 1891—Apple scab. The spraying of orchards.

No. 36 (Vol. IV, No. 10), December, 1891—Annual report and meteorological summary.

No. 37 (Vol. V, No. 1), January, 1892—Oats: Cultural and variety tests.

No. 38 (Vol. V, No. 2), February, 1892—Mangel wurzels and sugar beets.

No. 39 (Vol. V, No. 3), March, 1892—Fertilizers on corn and oats.

No. 40 (Vol. V, No. 4), April, 1892—Insects which burrow in the stem of wheat.

No. 41—Not published.

No. 42 (Vol. V, No. 5), August, 1892—Wheat: Cultural and variety tests.

No. 43 (Vol. V, No. 6), September, 1892—Greenhouses and greenhouse work. The food of the robin.

No. 44 (Vol. V, No. 7), September, 1892—The rusts of Ohio. Wild lettuce. Scab of wheat.

No. 45 (Vol. V, No. 8), December, 1892—Insects affecting the blackberry and raspberry.

No. 46 (Vol. V, No. 9), December, 1892—Underground insect destroyers of the wheat plant.

No. 47 (Vol V, No. 10), December, 1892—Annual report and meteorological summary.

No. 48, February, 1893—Profit in spraying orchards and vineyards.

No. 49, May, 1893—Field experiments with fertilizers.

No. 50, November, 1893—Experiments in feeding for milk.

No. 51, December, 1893—Miscellaneous entomological papers.

No. 52, December, 1893—Annual report and meteorological summary.

These bulletins are published at irregular intervals, those issued during each calendar year being paged consecutively and indexed in the annual report for that year.

In addition to the publications named above, the Station is issuing a "technical series" of bulletins, designed for the publication of lines of investigation which, while not immediately useful to the farmer, yet indirectly serve the cause of agriculture by furnishing data and suggestions bearing upon methods of research. Of this series three numbers have thus far been issued, namely:

TECHNICAL SERIES, VOL. I, NO. 1, OCTOBER, 1889.

Article I.—Preparatory stages of the twenty-spotted Ladybird. (Illustrated.) .... *C. M. Weed.*

Article II.—Studies in pond life. (Illustrated)........ *C. M. Weed.*

Article III.—A practical bibliography of insects affecting clover......... *C. M. Weed.*

TECHNICAL SERIES, VOL. I, NO. 2, MAY, 1890.

Article IV.—Flowering plants on the grounds of the Ohio State University .... *Moses Craig.*

Article V.—Fourth contribution to the life history of little known plant lice .... *C. M. Weed.*

Article VI.—Descriptive catalogue of the shells of Franklin county, Ohio. (Illustrated)........ *H. A. Surface.*

TECHNICAL SERIES, VOL. I, NO. 3, APRIL, 1893.

Article VII.—Methods of oviposition in the tipulidæ. (Illustrated)......*F. M. Webster.*

Article VIII.—A Dipterous gall-maker and its associates. (Illustrated.) .... *F. M. Webster.*

Article IX.—Description of a new species of gall-making diptera. (Illustrated.) .... *John Marten.*

Article X.—Description of a species of chlorops reared from galls on muhlenbergia mexicana .... *S. W. Williston.*

These bulletins are paged consecutively, and a complete index will be published in the final number of the volume. The bulletins of this series are sent only to other stations, to public libraries, scientific societies, and to such individuals as expressly request them.

A limited number of these bulletins can be furnished to applicants.

The Station also publishes a "newspaper bulletin," containing brief summaries of its work, and distributed only to the press and to such persons as particularly request it. One hundred and thirty-two numbers have thus far been issued in this series. Back numbers cannot be supplied.

ACKNOWLEDGMENTS.

The publishers of the following journals have aided the Station in its work during the year, either by republishing abstracts from its bulletins or by donating their publications to its library:

AGRICULTURAL PAPERS OF OHIO.

American Grange Bulletin, Cincinnati.
Farm and Fireside, Springfield.
Farmer's Home, Dayton.
Gleanings in Bee Culture, Medina.
Ohio Farmer, Cleveland.

GENERAL PAPERS OF OHIO.

Arcanum Enterprise, Arcanum.
Ashtabula News, Ashtabula.
Attica Journal, Attica.
Auglaize County Democrat, Wapakoneta.
Bakersville Press, Bakersville.
Barnesville Republican, Barnesville.
Cincinnati Price Current, Cincinnati.
Columbus Record, Columbus.
Cortland Herald, Cortland.
Crestline Advocate, Crestline.
De Graff Buckeye, De Graff.
Democratic Herald, Delaware.
Democratic Record, Chardon.
Forest Review, Forest.
Frederickstown Free Press, Frederickstown.
Fremont Journal, Fremont.
Geauga County Record, Chardon.
Geauga Leader, Burton.
Greenville Democrat, Greenville.
Herald, Middleport.
Industrial News, Toledo.
Jacksonian, Wooster.
Kenton Graphic News, Kenton.
Leader, Chillicothe.
Lewisburg Reporter, Lewisburg.
Lodi Review, Lodi.
Malta Register, Malta.
Monroe Journal (German), Woodsfield.
New Concord Enterprise, New Concord.
Northern Ohio Journal, Painesville.
Ohio State Journal, Columbus.
Painesville Telegram, Painesville.
Plain City Dealer, Plain City.
Press, Columbus.
Republican Leader, New Lisbon.
Shelby News, Shelby.
Tuscarawas Advocate, New Philadelphia.
Tuscarawas Chronicle, Uhrichsville and Dennison.
Union County Journal, Marysville.
Valley Enterprise, Milford.
Wayne County Democrat, Wooster.
Wayne County Herald, Wooster.
Wood County Democrat, Bowling Green.
Wooster Journal, Wooster.
Wooster Republican, Wooster.

MISCELLANEOUS PAPERS.

Agricultural.

Acker und Gartenbau Zeitung, Milwaukee, Wis.
Agricultural Epitomist, Indianapolis, Ind.

Agricultural Journal, Montgomery, Ala.
Agricultural Gazette, New South Wales.
American Agriculturist, New York, N. Y.
American Gardening, New York, N. Y.
American Homestead, Omaha, Neb.
American Rural Home, Rochester, N. Y.
Breeders' Gazette, Chicago, Ill.
California Cultivator and Poultry Keeper, Los Angeles, Cal.
Canadian Entomologist, London, Ont., Canada.
Colman's Rural World, St. Louis, Mo.
Cultivator, Omaha, Neb.
Dakota Farmer, Huron, South Dakota.
Farm and Home, Chicago, Ill., and Springfield, Mass.
Farmers' Advocate, London and Winnipeg, Canada.
Farm, Field and Fireside, Chicago, Ill.
Farm, Stock and Home, Minneapolis, Minn.
Florida Agriculturist, De Land, Fla.
Fruit Growers' Journal, Cobden, Ill.
Grange Visitor, Lansing, Mich.
Hoard's Dairyman, Ft. Atkinson, Wis.
Home and Farm, Louisville, Ky.
Husbandman, Binghamton, N. Y.
Industrial American, Lexington, Ky.
Indiana Farmer, Indianapolis, Ind.
Journal of Agriculture, St. Louis, Mo.
Maritime Agriculturist, St. John, N. B.
Mirror and Farmer, Manchester, N. H.
National Stockman and Farmer, Pittsburgh, Pa.
Orange Judd Farmer, Chicago, Ill.
Pacific Rural Press, San Francisco, Cal.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago Ill.
Rural New Yorker, New York, N. Y.
Rural Northwest, Portland, Oregon.
Southern Cultivator and Dixie Farmer, Atlanta, Ga.
Southern Planter, Richmond, Va.
Stock and Farm, Bunker Hill, Ind.
Sugar Beet, Philadelphia, Pa.
Weekly Globe and Canadian Farmer, Toronto, Canada.
Western Breeder, St. Joseph, Mo.
Western Farmer and Stockman, Sioux City, Iowa.
Western Resources, Lincoln, Neb.
Western Swineherd, Geneseo, Ill.
Wisconsin Farmer, Madison, Wis.

General.

Baltimore Weekly Sun, Baltimore, Md.
Boston Globe, Weekly, Boston, Mass.
Clover Leaf, South Bend, Ind.
Detroit Free Press, Weekly, Detroit, Mich.
Kansas Weekly Capital and Farm Journal, Topeka, Kansas.
National Provisioner, New York, N. Y.

Press, The Weekly, New York, N. Y.
Press, The Weekly, Philadelphia, Pa.
Science, New York, N. Y.
University Record, Ann Arbor, Mich.
Union, The Weekly, Manchester, N. H.
World, The Weekly, New York, N. Y.

IMPLEMENTS, SEEDS AND PLANTS RECEIVED.

Thanks are returned for the following donations to the Station:

AGRICULTURAL DEPARTMENT.

Castleton, Silas, Pomeroy, Ohio, seed corn.
Cranze, Eugene F., Ira, O., seed oats.
Graves, T. J., Dana, Ind., seed corn.
Newark Machine Co., Columbus, O., one Monarch fanning mill and grader.
Northrup, Braslin & Goodwin Co., Minneapolis, Minn., seed corn.
Pray, J. L., Waterville, O., seed corn.

HORTICULTURAL DEPARTMENT.

Bigelow & Co., Chicago, Ill., Oriental fertilizer and insect destroyer.
Brewer, S. F., St. Louis, Mo., 1 variety strawberry.
Burpee, W. A. & Co., Philadelphia, Pa., several pkts. seeds.
Cowing, Granville, Muncie, Ind., 1 variety strawberry.
Crawford, M., Cuyahoga Falls, O., 19 varieties strawberry plants.
Dow, Geo. Q., North Epping, N. H., 1 variety strawberry plants.
Gregory, J. J. H. & Son, Marblehead, Mass., 8 varieties vegetable seeds.
Hall, J. W., Marion Station, Md., 1 variety strawberry plants.
Hall, M. O., Marion Station, Md., 1 variety strawberry plants.
Halladay, A. A., Bellows Falls, Vt., 1 variety tomato seed.
Harris, S. M., Moreton Farm, N. Y., package of iodine.
Henderson, Peter & Co., New York, N. Y., 8 varieties grape vines.
Hoover & Gaines Co., The, Dayton, O., 1 variety strawberry plants.
Ingraham, Edward F., West Chester, Pa., 1 variety strawberry plants.
Lee, C. and C. L., Burbank, O., fruit picker.
Lee, H. S. and A. J., Geneva, Pa , 2 varieties strawberry plants.
Louisville Spirit Cured Tobacco Co., Louisville, Ky., 1 can rose leaf.
Luther, A., Leeds, Mo., 1 variety strawberry plants.
McGowen, John J., Forest Home, N. Y., spraying nozzle.
McKinley, J. S., Orient, O., 1 variety grape vine.
Mills, Chas., Fairmont, N. Y., 2 varieties raspberry plants.
Myers & Bros., Ashland, O., spraying nozzle.
Nichols, A. M. & Son, Granville, O., 1 variety tomato seed and 1 variety strawberry.
P. C. Lewis Mfg. Co., Catskill, N. Y., spray pump.
Perfection Sprayer Co., The, Waterton, Ind., spray pump.
Poscharsky, F. W. & Son, Princeton, Ill., 1 variety strawberry plants.
Read, L. H., Grand Rapids, Wis., 1 variety raspberry plant; also tomato and potato seed.
Riehl, E. A., Alton, Ill., 1 variety strawberry plants.
Sanders, A., Sac City, Iowa, 1 variety strawberry plants.

Stahl, William, Quincy, Ill., 1 knapsack spray pump.
Stiers, V. C. Haydenville, O., 1 variety tomato seed.
Stoneroad, V. D., Lewistown, Pa., 3 varieties potatoes.
Swably, G., Tiffin, O., 2 varieties strawberry plants.
Van Orman, F. B., Lewis, Iowa, 1 variety potato.
Warren, S. H., Weston, Mass., 1 variety strawberry plants.
West Jersey Nursery Co., The, Bridgeton, N. J, 3 varieties strawberry plants.
Woodbury, David B., Paris, Me., pansy seed.
Young, Henry, Ada, O., varieties strawberry plants.

The Monarch mill we have used three seasons, and recommend it for the special work of grading wheat for seed. As a fanning mill it lacks speed, but as a grader we think it is not excelled.

In conclusion, I have the pleasure of reporting another year of earnest, harmonious effort on the part of all connected with the Station.

Respectfully submitted,

CHAS. E. THORNE,
Director.

REPORT OF THE AGRICULTURIST.

J. FREMONT HICKMAN.

Owing to the change of base of operations from Columbus to Wooster, and to the unprepared condition of our new farm, the investigations carried on by this department have not been as satisfactory as in former years. The change has been from a warm, gravelly, naturally well drained and productive soil, to a cold, poorly drained and only moderately productive one. This wide difference in conditions makes it all the more essential that the experiments in field work conducted there should be repeated here. Our work during the past year has therefore been mainly a repetition of the experiments conducted on the farm at Columbus, and may be classified as follows:

I. Tests of varieties, including wheat, oats, corn, sorghum and sugar beets.

II. Cultural work with cereals.

III. Field experiments with commercial fertilizers in continuous cropping and in rotation.

IV. Testing forage crops, especially as to their adaptability to this soil, and including trials of certain grasses and clovers.

TESTS OF VARIETIES AND CULTURAL WORK.

Wheat: Our wheat experiments consisted of (a) a trial of seventy-five varieties for comparison of yields; (b) seeding at different rates per acre, from two pecks up to ten pecks, duplicating the plots by seeding with a different variety; (c) seeding with graded and ungraded seed, and mixing varieties for seeding; (d) various methods of seeding, such as deep and shallow planting, rolling before drilling on some plots and after drilling on others, seeding with the hoe drill and shoe drill, broadcasting compared with drilling, harrowing in spring and mulching in fall; (e) weighing stored grain each month during a year to determine shrinkage.

Oats: (a) Sixty-four varieties of oats were used in a comparative test; a number of these were duplicated and about one hundred varieties were sown in small plots for the purpose of studying synonyms. (b) Plowing corn stubble vs. harrowing, as a preparation for seeding to oats; (c) deep and shallow planting of oats contrasted.

Corn: (a) The varieties of corn in the comparative test for 1893 were all of the dent class, thirty-one in number. Twelve varieties were planted for ensilage; some of these were special ensilage sorts, others common field varieties. In addition to these variety tests at home I have attempted to have a co-operative test made by a number of farmers, covering some twelve counties of the State, to each of whom four varieties were sent. The main object of this co-operative test is to determine the maturing of the several varieties upon representative soils of the State. (b) Experiments in methods of culture were as follows: (1) contrasting deep and shallow culture; (2) distribution of seed, including hill and drill planting; (3) testing vitality of seed by planting continuously seed from same parts of the ear.

A limited experiment in deep and shallow plowing for corn was conducted on a piece of very stiff sod.

Sorghum: Five varieties of sorghum were planted, but only two out of the five matured, the season being too short for the other three.

Sugar Beets: Five varieties of sugar beets were planted to determine their comparative value as to sugar content; these have been harvested, sampled and turned over to the Station chemist.

FIELD EXPERIMENTS WITH COMMERCIAL FERTILIZERS.

These have been continued on the farm of the Ohio State University, covering twenty-two plots each of corn, oats and wheat. In this work the Station now has the results of five successive crops each of wheat and oats, and six successive crops of corn, taken from the same land. In the same field thirty-five plots are occupied with a five-year rotation. Experiments along the same line were begun on the new Station farm with corn last spring, but the wheat work was not begun until fall.

TESTING OF FORAGE CROPS.

This work has been given more attention this year than in previous years; more, however, with reference to their adaptability to our soil and climate than to their utility after they have been grown. The following were grown during the past season: five varieties of soja beans, one of spurry, one of rape and two varieties of cow peas. It is expected that a bulletin will be devoted to a few of these special crops.

Work has been begun on the growing of grasses of different varieties. A grass garden has been started in which five or six varieties of grass have been started and three or four sorts of clover; to these others will be added as the seasons come.

In seeding the wheat ground last spring, seven or eight mixtures of grass, and grass and clovers were sown. These mixtures included red

clover, mammoth clover, alsike, blue-grass, orchard grass, red-top and timothy.

FARM IMPROVEMENTS.

A large part of my time has been occupied during the year in superintending the construction of various farm improvements, as follows:

(1) About thirteen hundred rods of wire and picket fence were erected around the outside boundaries of the farm.

(2) An old "Pennsylvania" barn, about 40x80 feet in size, was entirely remodeled; this work included the raising of the barn about a foot; excavating the floor another foot and underpinning the foundation; inclosing the overshoot; putting down a grout and cement floor; putting in new stalls; adding a silo, a set of stock scales, and a water supply, including a new well, wind-mill and tank; re-grading the approach; excavating the barnyard and inclosing it with a tight fence, and constructing a cistern for liquid manure.

(3) A new stone range course and water table was put under the central brick farm house, and the entire course was covered with sheet copper to keep down the dampness. This work required skill, care and patience on the part of the workman, but it was successfully done.

(4) A stone culvert on the main drive between the central and east barn was begun but only partly finished when cold weather stopped the work.

(5) In addition to all the above, a little over twenty-six miles of tile drain have been laid on the farm; with the exception of five weeks in harvest, this work has demanded some attention and time every day from the middle of March to the middle of November. A part of a forthcoming bulletin will be devoted to some statements in detail concerning methods and cost of ditching.

In June thirty-two head of cattle (all steers), twenty-seven of them grade Short-horns and five grade Holsteins, were bought and put upon the farm, with a view to giving them all similar summer conditions preparatory to putting them into a feeding experiment during this winter. The cattle and barn are now ready, and the experiment will be carried on during the winter months.

FARM PRODUCTS.

In the following table is given the area of land occupied by the principal farm crops in 1893, the total and average yields per acre, and the price per unit in the local market at the close of the year. This table is given for future comparison with the general yields of the county

and state, as computed from the returns of the township assessors, and also as a record of prices:

Crop.	Acres.	Total produce.	Yield per acre.	Market price.
Wheat	50.5	1,220 bushels	24.0 bushels	$0.55
Wheat straw		77 tons	1.4 tons	3.00
Oats	30.0	580 bushels	19.3 bushels	0.35
Oat straw		30 tons	1.0 ton	3.00
Corn	25.5	540 bushels	21.1 bushels	0.40
Corn fodder (stover)		39 tons	1.5 tons	3.00
Ensilage corn	16.0	104 "	6.5 "	
Hay, timothy	60.0	105 "	1.75 "	9.00
Hay, clover	24.0	32 "	1.33 "	8.00

The very low yields of the corn and oat crops, as shown in the above table, were due to the lack of rainfall.

REPORT OF THE HORTICULTURIST.

W. J. GREEN.

The work in the horticultural department during the year has been largely preparatory for future operations. The four greenhouses, each 20x100 feet, which were put up in 1892, remained in an unfinished condition during the winter. An attempt was made to heat two of the houses with stoves and a portable engine, but this was only partially successful, and some important experiments which had been begun at Columbus in sub-irrigation could not be completed as had been anticipated. Some lettuce and tomatoes were grown, but the experiments with these crops had to be abandoned. During the summer, heating apparatus was put in and benches erected. The houses thus far have been devoted almost wholly to experiments in sub-irrigation with lettuce, cauliflower, cucumbers, radishes, tomatoes, beets, strawberries, carnations, roses, smilax, sweet peas and violets. Thus far most of the work is progressing in a very satisfactory manner. No experiment is yet completed, but not a failure to grow any kind of plant by sub-irrigation has been made. As might be expected, some plants do better than others under this treatment, but all are more or less improved by it, while with some the crop is often doubled. The work will probably be sufficiently advanced by the close of winter to warrant the publication of a bulletin giving details of methods and results early in the summer.

The necessity of water-tight benches for sub-irrigation has led to some important inventions in this line. It is found that a water-tight bench can be constructed of non-rotting materials at a moderate cost above ordinary lumber benches. These improvements will also be described in the bulletin referred to. The houses have improved ventilators, water benches, a plentiful supply of hose, and water piped to convenient places. Although some improvements could be made in the erection of similar houses, they are well adapted to the purposes of experimentation, and may to some extent serve as models in construction.

The highest land on the farm was chosen for the location of orchards and gardens, and the following fruits were planted:

Apples, 231 trees, comprising 77 varieties.

Pears, standard and dwarf, 222 trees, comprising 72 varieties.

Plums, 199 trees, comprising 68 varieties.

Apricots, 5 trees, comprising 5 varieties.
Cherries, 75 trees, comprising 25 varieties.
Peaches, 147 trees, comprising 35 varieties.

Blackberries, 13 varieties, raspberries, 23 varieties, grapes, 43 varieties, also currants, gooseberries, buffalo berry, Rocky Mountain cherry, june-berries, and 100 varieties of strawberries, nearly half of which are new sorts that have been sent to the Station for trial. The total area in fruits is about fifteen acres.

All of the tree fruits were so arranged in planting as to admit not only of variety tests, but of experiments in spraying. The experiment of spraying to prevent fungous diseases gaining a foothold was commenced soon after the planting. Certain trees are to be sprayed several times each year, while others are to be left untreated, and the effect noted from time to time.

In the selection of varieties the leading kinds were first taken, and the newer ones added. Old, well known sorts of doubtful value were not included. In most cases three trees of each variety were planted, although this rule was not followed strictly.

A small nursery of both fruit and ornamental trees has been started from which to draw supplies as needed. The list of ornamental trees and shrubs includes upward of one hundred species and varieties. All of these will be needed on the grounds, and a considerable saving in cost will thus be effected, as the plants being small were purchased at low figures.

No fruit was grown except a few peaches, and some strawberries on plants set the previous autumn. A brief report of these varieties will be given in a bulletin soon to be issued. A number of varieties of potatoes were grown, and some fertilizer tests conducted, a report of which will be given in due time.

Considerable attention was given to the tomato crop, particularly with reference to methods of training. A comparison on a considerable scale was made between staked and unstaked tomatoes, and some valuable results obtained, which will be embodied in a bulletin. Staking was found to hasten the time of ripening, to increase the size and to reduce the amount of rot. The extra labor was more than paid for in the higher prices obtained, because of extra size and earliness.

Some work in spraying was carried on, but owing to lack of bloom there was not sufficient fruit to admit of any decisive results. The most striking fact noted was that the blister beetles, more commonly called "old fashioned potato bugs," are repelled by Bordeaux mixture. Whereever this compound was used thoroughly, the bugs left the potato plants and either attacked weeds or unsprayed potatoes. Considerable benefit was found in the use of the Bordeaux mixture on tomato plants in keeping the foliage healthy, although the rot was not prevented.

REPORT OF THE ENTOMOLOGIST.

F. M. WEBSTER.

Owing to the continued unsettled condition of affairs with reference to buildings and other necessary facilities for carrying out investigations of a nature demanding close attention and equipment for doing things at the proper time, considerable work cannot as yet be carried out. As an illustration, a few days delay in the completion of the benches in the insectary last spring wrecked nearly a whole years experiments in wheat insects. Later, however, I was enabled to carry out an experiment with the apple leaf plant louse, *Aphis mali* Fab., and settle a question that has been under consideration for a number of years, but a lack of proper facilities had prevented its completion. In the insectary, I was able to follow the migration of this insect of the orchard directly to both wheat and grasses, and thereby settle the fact of its change of food plant, to return again in the fall to oviposit on the apple trees.

The rearing of parasitic insects beneficial to agriculture and horticulture resulted in very gratifying success. Since the preparation of number 3, of the Technical Series, twelve species not previously known to science were reared, and notes and observations on their habits placed on record. These species are as follows: *Hexaplasta melanopus* Ashm., *Bracon fungicola* Ashm., *Bracon rhyssamati* Ashm., *Clinocentrus tarsalis* Ashm., *Pygostolus americanus* Ashm., *Phænocarpa fungicola* Ashm., *Mesoleptus fungicola* Ashm., *Meniscus 4-cinctus* Ashm., *Syntomophus americanus* Ashm., *Polyscelis websteri* Ashm., *Chrysocharis compressicornis* Ashm., and *Tetrastichoides lasiopteræ* Ashm. Notwithstanding the fact that black knot, *Plowrightia morbosa* is not caused by insects, except as they are instrumental in the distribution of the spores, quite a number of species were reared therefrom, one of them being the American plum borer, *Euzophora semifuneralis*, not previously reported from Ohio. In June a trip was made to the strawberry fields about Marietta in order to investigate the effect of a species of Aleurodes which had appeared in great numbers in some of these fields. It was found that while the insect bred on the plants, it did no harm, the injury attributed to it being caused by a lack of fertilization. Much time during the season was spent in the study of the Rose Chafer, *Macrodactylus subspinosus*, and it was

learned for the first time that the larvæ could develop in great numbers in fields of fall wheat. This investigation is as yet unfinished, and a full report can not now be made. Three entirely new corn insects were studied in Ashtabula county, viz., *Hadena fractilinea*, *Hadena misera* Gt., and *Crambus luteolellus* Clem.

The Western corn root worm, *Diabrotica longicornis* occupied considerable time, it being a new pest to the corn crop in Ohio. A trip over the C., H. & D. R. R., along the western part of the State, indicated its occurrence in destructive abundance for a considerable distance east of the Indiana line, throughout nearly the entire length of the State, and especially in the Miami valley.

A serious injury to grapes, especially the Worden variety, has developed in the vineyards along the lake shore east of Cleveland. A small, white larva attacks the roots and eats the bark to such an extent that the life of the vine is destroyed. On rearing these larvæ, the pest was found to be *Fidia viticida* Walsh., and, although the adult beetle has long been known to feed on the foliage of the grape, the larvæ have heretofore remained unknown. These larvæ resemble some of the strawberry root worms, and during the winter and early spring are found in the earth in the vicinity of the roots. The beetle is a small brown or chestnut colored insect that will probably be mistaken, by the unentomological, for the rose bug, although it is much smaller and the two are in no way related.

The appearance of the Asparagus beetle, *Crioceris asparagi*, in the vicinity of Cleveland was investigated, and so far as known, the only colony occurring in that vicinity was destroyed by the use of Pyrethrum.

Among the insects on which more or less extended observations have been made is a large bug, allied to the squash bug, and for which there is no common name (being *Euschistus variolarius* P. Beauv.), that proved quite injurious to ripening tomatoes by puncturing the skin and sucking the juices. Peaches were attacked in the same manner. The Clover Leaf Weevil, *Phytonomus punctatus*, was found to feed in the adult stage on both burdock, *Lappa officinalis*, and the bloom of the solidago or golden rod. The larvæ appeared to prefer the leaves of the white clover to those of the red.

The Grave Yard Beetle, *Otiorrhynchus ovatus*, was reared from larva found feeding on the roots of the blue grass.

A corn Bill Bug, *Sphenophorus parvulus*, Gyll. was observed destroying an entire field of corn in Ashtabula county in June, and under circumstances indicating that fall plowing might result in driving the pest from the fields before the crop was planted.

A small Flea Beetle, *Epitrix parvula* Fab., was observed depredating on tobacco in Hamilton county in August.

The Bag or Basket Worm, *Thyridopteryx ephemeræformis* Haw., has been especially injurious this season in southern Ohio—it does not occur

elsewhere in the State—and I have nothing new to record except that about North Bend it is parasitized to a limited extent by a Dipteron, probably a Tachinid, as I have found the pupa protruding from the lower or posterior end of the sack and somewhat resembling the anterior end of the pupa of the male Thyridopteryx, as the latter is first pushed forth, preparatory to the emerging of the imago. The same parasite, or what has the appearance of being the same, has also been received from Indiana.

The last legislature of Ohio appropriated $400 for the expenses of special investigations in entomology, which will enable the entomologist to visit localities and investigate different insects and their depredations in the field, and thus be better able to aid the farmer and fruit grower than has been possible to do heretofore.

F. M. WEBSTER,
Entomologist.

REPORT OF THE CHEMIST.

F. J. FALKENBACH.

The past year has been devoted mainly to the collection and analysis of feeding stuffs for use in feeding experiments conducted at the Station.

Analyses of six samples of milk were made in connection with a prize offered by the State Board of Agriculture.

Samples of water sent in by different parties were tested for actual ammonia, albuminoid ammonia, chlorine, solids at 100° C., solids at red heat and hardness. The analyses of these will be found in a table below.

Analyses were made of 108 samples of wheat grown on the Station farm. These will be published in a future bulletin.

The dry matter was determined in eleven samples of ensilage.

Six varieties of sorghum cane were tested for sugar.

Analyses were made of six varieties of sugar beet.

One sample of bone soup tested for amounts of solids, nitrogen and phosphoric acid.

One sample of beef tested for amounts of dry matter, nitrogen and phosphoric acid.

Several samples of Wayne county clays were analyzed. The results are given in a table following.

The analyses of water were made according to Wancklyn's process. Mr. Wancklyn's interpretation of the results of his mode of investigation is as follows:

1. Chlorine alone does not indicate the presence of filthy water.

2. Free and albuminoid ammonia in water without chlorine indicates a vegetable source of contamination.

3. More than five grains per gallon of chlorine, accompanied by more than .08 parts per million of free ammonia and more than .10 parts per million of albuminoid ammonia indicates that the water is contaminated with sewage, decaying animal matter, etc., and should be condemned.

4. Eight hundredths parts per million of free ammonia and one tenth part per million of albuminoid ammonia render a water very suspicious even without much chlorine.

5. Albuminoid ammonia, over fifteen hundredths parts per million, ought absolutely to condemn a water which contains it.

6. The total solids found in water should not exceed 40 grains per gallon (571.4 parts per million).

TABLE I.—Analyses of Water.

Parts Per Million.

Number.	Actual ammonia.	Albuminoid ammonia.	Chlorine.	Solids at 100° C.	Solids at red heat.	Hardness.* (Clark's degrees.)
44	.053	.130	3.00	118.00	58.00	3.02
47	.014	.180	45 00	500.00	320.00	14.10
48	.160	.260	142.00	1,165 00	500.00	29.80
49	.040	.076	67.00	498.00	313 00	13.90
50	.054	.170	5.00	297.00	122.00	14.20
55	.040	.220	12.00	200.00	145.00	4.10
56	.093	.140	26.00	145.00	75.00	4.40
61	.026	.030	4.00	235.00	90 00	11.10
62	013	.070	32.00	595 00	225 00	14.40
63	.026	.160	57.00	530.00	255 00	13.00
64	.054	.100	6.00	450.00	120 00	9.10
65	.206	.980	58.00	640.00	135.00	10.13

*Degrees of hardness: 1°–5°, soft; 5°–10°, medium; 10°–15°, hard; 15° and above, very hard.

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TABLE II.—ANALYSIS OF CLAYS FOUND IN WAYNE COUNTY.

PARTS PER HUNDRED.

	Combined water.	Silica.	Sesqui oxide of iron.	Alumina.	Lime.	Magnesia.	Fixed alkalies.
Fire clay	15.66	48.43	2.86	17.02	11 23	3.79	.83
Shale	6.28	57.24	6.57	24.63	1.59	1 48	1.63
Feldspathic clay	12.70	46.05	1.15	38 42	.46	.15	1.03
Brown clay shale	12.57	45.20	1 00	39.67	.42	.27	61
Plastic clay	8.10	60.43	1.39	27.81	.65	.18	1.27
Clay	7.30	59.61	5.84	21.94	2.45	1.36	1.01
Clay	8.61	56.55	6.44	21.71	2.85	1.45	1.61

ERRATA.

Page 33. The yields of straw for 1889 on plots 10 and 15 should be 3,960 and 4,060, respectively.

Page 62. The temperature scale should read 20° instead of 30°; 30° instead of 40°, etc.

Page 82. Second line from bottom, for "already" read "always."

APPENDIX.

BULLETIN

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION

VOL. VI. SECOND SERIES. 1893.

CONTENTS.

BULLETIN

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

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PROFIT IN SPRAYING ORCHARDS AND VINEYARDS.

BY W. J. GREEN.

Ohio has more than half a million acres of orchards and vineyards, and all of the trees and vines covering these acres are subject to the attacks of insects and fungous diseases. How much damage these insects and diseases do, or are capable of doing, cannot well be estimated, but it is possible to approximate quite closely to the benefit to be derived from the use of preventive and remedial measures against them. It was demonstrated at this Station in 1891 that a certain course of treatment enhanced the value of the apple crop not less than $20.00 per acre, and in 1892 the same treatment prevented a loss of a still greater amount.

The value of treatment to prevent premature leaf dropping of plum and pear trees, in connection with the use of Paris green for the curculio, is even greater than in the case of apples. Treatment for the grape rot yields still higher returns. Although all classes of insects and all fungous diseases cannot be successfully controlled, enough is known concerning methods of treatment to warrant the statement that were these methods put into practice generally, the returns from the fruit crop of the state would annually exceed its present value by several millions of dollars. Full demonstration of the truth of this statement may be found in the reports and bulletins issued by the United States Department of Agriculture and by the various experiment stations.

The design of this bulletin is not so much to add more facts by way of further demonstration, as to put into available form such instructions as are needed by those who have not followed the work of this and other experiment stations. It is something of a departure from the method of giving the results of experiments, mainly, instead of instructions, but the numerous letters of inquiry, and questions asked at institutes, show that there is interest in the subject, and that many are in need of further light. Even those who have given the matter considerable attention have become somewhat confused, owing to the variety of mixtures recommended by different experimenters, and to the unfamiliar names of chemicals.

Combined Mixtures.

It is not proposed, however, to cover the whole field of spraying operations, but to confine the limits of the bulletin almost entirely to the consideration of the treatment of some of the most destructive fungous diseases and most troublesome insects affecting fruit trees, in one operation, by the use of combined mixtures. For certain reasons this plan will be departed from to some extent, but the subject of combination fungicides and insecticides is of sufficient importance to merit special prominence.

Combined mixtures have a wider range of usefulness than is commonly supposed; in fact our leading fruit crops may be best treated in this manner. In most cases where either Paris green or London purple is to be used for insects it is much better to apply them in connection with Bordeaux mixture than alone, and in some cases where the treatment is specially for a fungous disease it is well to add an arsenite. The following reasons may be assigned for using arsenites (London purple and Paris green) in combination with Bordeaux mixture:

(1.) Where both are required, time is saved by using them in combination.

(2.) The Bordeaux mixture prevents the arsenite doing harm to the foliage.

(3.) Either is quite as efficient in combination as alone, and in some cases more so.

(4.) It is not always known whether one or both are needed, hence as a precaution it is better to use both in combination.

Mixtures Used in Spraying.

Dilute Bordeaux mixture:

Copper sulphate (blue vitrol) 4 pounds.
Quick lime, 4 pounds.
Water, 50 gallons.

Dissolve the copper sulphate in two gallons of hot water, and pour into the barrel or tank used in spraying, after which fill the tank nearly half full of cold water. Slake the lime in another vessel and pour into the copper sulphate solution, straining through a brass wire strainer with about thirty meshes to the inch. The lime will not dissolve readily, hence after pouring off each time more water is to be added to the lime and poured off as before, until nearly all the lime is dissolved, or taken up in suspension, which is really the case. Water to make 40 or 50 gallons in all is then to be added.

A stronger mixture is somtimes made by using three or four times the quantities of copper sulphate and lime above specified.

Cautions: Do not use air slaked lime, and do not slake the lime in large quantities and allow to stand before using. Do not mix the copper sulphate solution and lime water before cooling by the addition of water, as above directed.

Copper-arsenic solution.

Copper carbonate, 6 ounces.
Paris green, 4 ounces.
Ammonia, 2 quarts.
Lime water, 50 gallons.

The copper carbonate and Paris green may be mixed and dissolved in the ammonia (more or less ammonia will be required according to strength), after which add the lime water. By lime water is here meant clear lime water made by dissolving as much lime in water as it will take up. One-fourth pound of lime to a barrel of water is as much as is required for the purpose of preventing the injury to the foliage which the Paris green might cause. A convenient method is to put several pounds of lime in a barrel and then fill with water; after stirring vigorously allow to settle, when the clear water may be used. The barrel may be filled with water each time before going to the orchard and allowed to stand while gone.

Cautions: Use enough ammonia to dissolve the Paris green and copper carbonate, but no more, and no more lime than above specified:

Ammoniacal solution of copper carbonate.

Copper carbonate, 6 ounces.
Ammonia, 3 pints.
Water, 50 gallons.

Dissolve the copper carbonate in the ammonia and add the water.

Caution: Use no more ammonia than is required to dissolve the copper carbonate. Ammonia is variable in strength, and the amount required must be tested in practice.

To make copper carbonate at a cost of one-third the usual price: Dissolve 10 pounds copper sulphate (blue vitriol) in 10 gallons of hot water, also 12 pounds carbonate of soda in same quantity of water. After cooling, mix the two solutions and stir well. Allow the mixture to stand twenty-four hours and settle, after which pour off the liquid. Add the same quantity of water as before, stir and allow to stand same length of of time. Repeat the operation again, after which drain and dry the blue powder, which is copper carbonate.

Numerous other mixtures have been used and recommended by experimenters, but the above have been found to be satisfactory, and for various reasons are believed to be the best for general use. The Bordeaux mixture is the most useful of all, but in certain cases, which will

be specified, one of the others may take its place. The arsenites, London purple, Paris green, or white arsenic, may be employed to destroy such insects as are mentioned in this bulletin, but the first named is preferable in most cases, because of its cheapness, although Paris green has the advantage of being an insecticide and to some extent a fungicide, as it contains some copper. If used in combination with Bordeaux mixture they are not likely to injure the foliage, but if applied alone London purple is more harmful than Paris green, and must be used with care, and especial pains taken to keep the mixture well stirred, so as not to allow any of the poison to settle to the bottom of the barrel, as in that case the last portion, being too strong, is likely to burn the foliage, and the first part may be too weak to do any good.

When to Spray.

Under each fruit mentioned in the following pages the proper time for spraying will be given, but it is desired to draw attention to and to emphasize one important fact, viz.: *treatment with fungicides is preventive, not remedial.* After a fungous disease has become established it cannot be cured, but it can be prevented, if preventable, if treatment is begun in time, hence it is important that the first application should be made early, generally before the leaves open, or, soon after.

It is too late to begin making applications of fungicides after the disease has made its appearance.

It should be remembered also that it is not always possible to wait for pleasant weather when spraying is to be done, but if good results are to be secured, the work cannot be delayed for any considerable length of time, hence it often becomes necessary to spray just before, or soon after a rain. In fact, nothing short of an actual rain storm should stop the work when the time comes when it should be done. Properly prepared mixtures will stick to the foliage, even through hard rain storms, provided they have half an hour in which to dry. Cloudy weather, or the appearance of rain, should not hinder the work.

Insecticides are not applied until the insects make their appearance, but it is not best to delay much longer than that time.

In order to answer numerous queries which have been made within the year, and to present certain facts as clearly as possible, each fruit will be considered by itself. This necessitates some repetition, but many of the questions asked show that considerable confusion exists regarding the various methods to be pursued in the treatment of different fruits. Especially is this true regarding the use of combination fungicides and insecticides. It will be necessary to go over some of the same ground covered in bulletin No. 9, Vol. IV, of this station, issued December, 1891; but the facts presented are for the most part new, and the methods of treatment have been modified to some extent,

Spraying the Plum.

The most troublesome insect affecting this fruit is the plum curculio. It has been repeatedly affirmed in bulletins published by this Station that the curculio can be controlled by spraying three or four times during the season with Paris green, and later experiments confirm these statements. A practical difficulty exists, however, in the fact that no matter how dilute the mixture, there is danger of injuring the foliage. This is due for the most part to the fact that the foliage of plum trees is seldom free from the disease commonly known as the shot-hole fungus, a name descriptive of a disease which causes the leaves to drop prematurely. This early dropping of the leaves injures the trees and prevents the proper development and ripening of the fruit. It becomes a necessity, therefore, to treat the foliage for the disease, whether the curculios are caught by jarring, or poisoned with Paris green, and particularly if the latter method is followed.

It follows, then, that the best mixture to use on plums is a combination, containing a fungicide and insecticide. This course was advised in the December bulletin of 1891, and further trial confirms the statements there made. Even those who hesitate to use Paris green admit the efficacy of the dilute Bordeaux mixture, and those who have fully tested both agree that the combination is entirely satisfactory. The formula for dilute Bordeaux mixture given on page 4 is used, and two ounces of Paris green or London purple added. This mixture is to be applied with a suitable force pump as soon as the blossoms have fallen, and repeated three or four times at intervals of one week. There does not seem to be any necessity for more than four applications, and three have been found to answer very well.

The treatment here outlined does not seem to prevent the plum rot to any extent. This disease is due to a specific fungus, but many growers, knowing the habit of the young brood of curculios of biting into the fruit late in the season, have attributed the rotting of it wholly to this cause, hence have taken no pains to destroy the dried plums which hang on the trees over winter. It is probable that these punctures made by the curculios late in the season afford a starting place for the plum-rot fungus, but no method can be given at present for preventing the rot, better than that often advised of picking off and burning the dried plums in the fall or winter. An early application of the Bordeaux mixture might also be advisable. One or two sprayings with two ounces of Paris green to fifty gallons of water might be safely made, after the time advised for the discontinuance of the Bordeaux mixture, provided the foliage is sufficiently healthy. This plan has not been tested, however, and should be cautiously tried. Jarring may become necessary in case the curculios are abundant late in the season.

The question has been repeatedly asked, will spraying with fungicides prevent the black knot? This question cannot be answered, as the matter has not been tested by experiment. The black knot can be controlled, however, by burning all badly diseased trees, and the affected branches of trees not seriously attacked. Diseased branches must be cut away and burned during the fall and winter. Possibly the spraying advised for the leaf disease will have some effect in checking the black knot, but it would not likely prevent it wholly. These directions apply to European varieties only. See "Spraying the Peach" for treatment of American varieties.

Cautions: Do not spray when the trees are in bloom, but do not delay making the first application more than a day or two after the blossoms have fallen. Do not continue much longer than advised, for the reason that the mixture, if applied too late, will stick to the fruit until after it is ripe. Fruit with a considerable quantity of the mixture adhering may be eaten without danger to the health, but such fruit is unmarketable, and washing is not practicable.

Spraying the Apple.

Our bulletin of December, 1891, shows conclusively that spraying to prevent the apple scab is beneficial and highly profitable. Some additional facts have since been noted which are deserving of special mention.

In the fall of 1891 a duplicate series of experiments was commenced with Baldwin, Bellflower, Newtown Pippin, Northern Spy, Smith's Cider and Seek-no-further to determine the relative keeping qualities of scabby apples and those free from scab. One hundred apples from each lot were selected, the scabby ones taken from the unsprayed, and those free from scab from the sprayed. All that showed indications of decay as well as all wormy specimens were rejected. Essentially the same results were obtained with the different lots. There were such variations as might be expected, but none contrary to the general rule, which was manifest in all cases, and may be stated as follows:

Apples free from scab kept better than scabby apples, but the greatest difference in keeping qualities was shown soon after the fruit was stored. This difference gradually diminished until the keeping qualities of both lots were nearly the same, but some of those free from scab were found to be sound for some time after all of the scabby apples had rotted.

The following example, taken from the results secured with the Newtown Pippin, illustrates the above statements: The apples were stored October 30, and were examined at frequent intervals. The total numbers found to be rotten at certain dates are given.

	Dec. 4.	Dec. 25.	Feb. 19.	Mar. 30.	May 8.	June 14.
Free from scab, whole number rotten,	4,	13,	45,	66,	79,	100.
Scabby, whole number rotten,	12,	27,	78,	93,	100.	

In the first period, of a little more than a month, three times as many of the scabby as of those free from scab rotted, and with several other varieties the difference was nearly as great. The average number rotten in ten lots was 25 not scabby to 40 of the scabby. A more marked difference was shown in most varieties at the end of the first period of two weeks. If we take all the varieties except Newtown Pippin (none of which had rotted at the end of two weeks) it is found that on an average 5 not scabby had rotted to 13 of the scabby. If we compare those lots which kept until February 19, we find that 71 not scabby and 87 scabby had rotted.

This shows clearly that the effect of the apple scab in causing rot is most marked at an early date, or soon after the apples are picked and stored. No doubt it often causes rot before the apples are gathered. The scab fungus, is, of course, only indirectly the cause of rot, but it undoubtedly is the source of great losses to orchardists. Probably fifty per cent. of the early decay of apples can be prevented by the use of proper remedies. Spraying to prevent the apple scab would no doubt pay, if for no other purpose than to improve the keeping qualities of the fruit.

The spring and early part of summer of 1892 was noted for the great amount of rainfall, and the work of spraying was seriously interfered with. The same orchard of Newtown Pippins was operated upon as in the season previous. Different mixtures were tested, but owing to the excessive rainfall some were washed off more than others, hence a fair comparison could not be made. The crop was not good in any part of the orchard, but one fact may be mentioned as worthy of notice: Three rows, running across the orchard, were left unsprayed, but none of the trees in these rows had any apples on worth picking, and but few of any kind. Had the entire orchard been left unsprayed the crop failure would have been the same on all parts, and the explanation that the frequent rains prevented pollenization of the blossoms would have been considered sufficient. There was sufficient bloom for a fair crop, but the above cause cannot be assigned, for the reason that on the sprayed trees there was a partial crop, differing of course according to the efficacy, or rather to the adhesive quality, of the mixtures. Four rows on the east side and four on the west side of the orchard were sprayed with the dilute Bordeaux mixture, and these rows were the only ones where anything like a satisfactory crop was found. That the application of this compound saved at least one-third of a crop is undeniable, but in what way was this result accomplished? When the young fruit is severely

attacked by apple scab it is often destroyed, and the action of the Bordeaux mixture was to prevent this to some extent, hence the partial crop where it was applied. At present this explanation seems tenable, and no other can be offered which will meet the case. Further confirmation is necessary before this belief can be established beyond a doubt, but it may be accepted as a good working hypothesis. It is not likely to lead to any serious consequences in practice, and may be the means of saving crops that would otherwise be lost. On another plot the treatment was with the same mixture, but the first application was omitted. The difference between this and the other two plots was considerably in favor of the early spraying.

It thus appears that the mixture used must be adhesive, and the first application must be made early in the season, before the buds open. There can be no question regarding the correctness of these conclusions, but the claim is not made that early spraying with any particular mixture will always insure a crop. Much depends upon the weather and other conditions. When the rainfall is abundant, and other conditions favorable for the early development of the scab fungus, the proper use of fungicides may be expected to have an effect similar to that above indicated, but in seasons when the scab finds unfavorable conditions for development the same treatment would show less marked results. The scab does more or less injury in all seasons, but it does not always get sufficiently started early enough to cause the destruction of the young fruit; but whatever the character of the season, early spraying is advisable.

In the December bulletin of 1891, one spraying was advised before blooming and three after; but it is now believed that it is better to make two applications before blooming and two after. The first is to be made just before the buds open, using either dilute or strong Bordeaux mixture, but preferably the latter. The second is to be made just before the blossoms open, using the same compound. For the third application, which should be made as soon as the blossoms have fallen, use the dilute Bordeaux mixture and to this add four ounces, or one-fourth of a pound, of Paris green or London purple to fifty gallons of the mixture. About this time the codlin moth lays its eggs in the blossom end or calyx of the apples. These eggs soon hatch and the young worms are killed by eating the poison, which explains its use. Another application of the same combination mixture should be made within ten days from the time of the third spraying. No further spraying during the season is advised. If desired, the ammoniacal solution of copper carbonate may be used some weeks later, but it is better to discontinue the use of the Bordeaux mixture at the time specified, as it sometimes causes a russet appearance on the fruit if applied too late. So far as observed, late applications have not been very beneficial, and four seem to be sufficient. This mat-

ter has not been fully settled by experiment, but no doubt much depends upon the compound used, the weather, the variety of fruit and the manner in which the work is done.

Cautions: Do not spray when the trees are in bloom, and do not delay the third application more than three or four days after the blossoms have fallen. If for any reason either London purple or Paris green is used alone, do not take more than one-fourth of a pound to fifty gallons of water. Do not use Bordeaux mixture later than specified on early apples nor upon white or yellow skinned sorts.

Spraying the Pear.

The pear is affected by a number of fungi and insects, some of which are the same as those found on the apple, and the treatment advised is nearly the same. The fruit is discolored by a fungus and the leaves drop prematurely from the same cause. The apple worm is found in the pear as well as in the apple; the plum curculio is more troublesome in pears than in apples; in fact, in many localities the necessity of keeping the curculio from injuring pears is quite as great as in the case of plums. The slug often does serious damage to pear leaves.

All of these enemies to the pear may be controlled by the use of combined mixtures, for insects and fungi. The first and second sprayings should be made with Bordeaux mixture, as advised for apples, although two applications before the time of blooming do not seem to be so necessary as in the case of apples, as the treatment seems to be more effective on the former than upon the latter.

The treatment after blooming may be the same as outlined for apples, but as the Bordeaux mixture, if used more than twice after blooming, causes a russet appearance on the fruit it is well to substitute the copper arsenic solution. Three or four sprayings should be made with this compound, commencing as soon as the blossoms have fallen, and continuing as long as the curculios appear to be working. The applications are to be made at intervals of about one week, and three are usually sufficient, but four or five will do no harm if the solution is properly prepared.

The scab on the pear causes early rotting, as with apples, and possibly in a still more marked degree. The cost of spraying will be repaid in the preservation of the fruit from rotting, if in no other particular.

Will spraying with fungicides prevent pear blight? This question has been asked many times at farmers' institutes, but no experiments have been made to determine what effect, if any, spraying has upon the blight. Probably spraying with fungicides can have no more than an indirect effect, by keeping the trees healthy and thus enabling them to

resist the blight to some extent. The matter is referred to here for the reason that the belief seems to be held by many that spraying with fungicides ought to prevent blight as well as other diseases.

Cautions: Do not use the Bordeaux mixture more than once after the time of blooming on early pears, nor more than twice after this period on any variety. Do not make the periods between the applications of the copper arsenic solution longer than ten days, and discontinue its use on early varieties at least a month before ripening.

Spraying the Quince.

Treat the same as recommended for the apple, or use Bordeaux mixture alone.

Spraying the Cherry.

The curculio, which causes cherries to be wormy, may be controlled by the use of Paris green. A fungous disease often causes many of the leaves to drop early in the season. Bordeaux mixture was tried for this the past season, but seemed to have an injurious effect upon the foliage, as more leaves dropped where it was used than where it was not.

Caution: Do not use London purple on cherry trees, and of Paris green not more than two ounces to fifty gallons of water, and make only two applications to early and three to late varieties.

Spraying the Peach.

The foliage of the peach is very easily injured, and will not bear the spraying requisite to keep the curculio in check. Early in the season, and sometimes later, a single application of Paris green, at the rate of two ounces to fifty gallons of water will do but little harm, but when the same mixture is applied several times in succession, as must be done for the curculio, the leaves usually drop quite badly in consequence. The liability to injure the foliage does not seem to be wholly avoided when Paris green and Bordeaux mixture are used in combination. These facts are stated in order that those who think of spraying peach trees may be on their guard. It is possible that the good effects in preventing the rot would be more than overbalanced by the slight harm done to the foliage, but this is still an open question. At present the best advice that can be given is to make not more than two applications, soon after blooming, using two pounds each of copper sulphate and quicklime and two ounces of Paris green to fifty gallons of water. This will do some good and not very much harm.

The same remarks and directions apply to the American varieties of plums, as the foliage of these is quite as tender as that of the peach.

Spraying Raspberries, Grapes and Potatoes.

Numerous queries have been received concerning the treatment for raspberry-cane scab, or anthracnose, grape rot and potato blight.

The raspberry anthracnose was treated quite fully in our bulletin of October, 1891, and if any change is to be advised it is to use a weaker solution. Two pounds each of copper sulphate and quicklime would no doubt be sufficient, although this strength has not been fully tested.

For grapes the stronger Bordeaux mixture should be used for the first, second and third applications, which should be made just before the buds open, just before the time of blooming, and soon after the grapes are set. Two or three applications should be made thereafter with the ammoniacal copper carbonate solution, but do not use the Bordeaux mixture later than specified.

Potatoes should be treated with Bordeaux mixture and Paris green, at least five times during the season, commencing as soon as they are six inches high.

Summary.

(1.) The profit to be derived from spraying orchards often exceeds $20.00 per acre, and for vineyards is much more. The fruit crop of the state would be enhanced in value by several million dollars annually if the practice were generally followed.

(2.) Combined fungicides and insecticides are recommended whenever applicable, because of a saving of time; a less liability of injuring foliage; greater efficiency in some cases, and as a precautionary measure in others.

(3.) Dilute Bordeaux mixture, copper-arsenic solution and ammoniacal solution of copper carbonate are the most useful for the treatment of the diseases herein mentioned, and the first has the widest range of usefulness of all.

(4.) Early spraying is the key to success in the use of fungicides.

(5.) For the plum curculio and shot-hole fungus use Bordeaux mixture and Paris green combined, making three or four applications.

It is not known that this treatment will prevent the black knot, but cutting away and burning the diseased branches will accomplish the result.

(6.) Scabby apples rot much earlier than those free from scab, and spraying with fungicides will save at least 50 per cent. of this loss.

(7.) Spraying with fungicides in the season of 1892 prevented much of the early dropping of apples, which is usually attributed to wet weather.

(8.) For apples, two applications of Bordeaux mixture before blooming are advised, and two of the same mixture after blooming, with Paris green added.

(9.) The same treatment is recommended for the pear as for the the apple, before blooming, but the copper-arsenic solution is advised after blooming.

(10.) The Bordeaux mixture, if used too late, causes a russet appearance on both pears and apples.

(11.) The quince may be treated the same as apples, or with Bordeaux mixture alone.

(12.) The treatment advised for the cherry consists in making two or three applications of Paris green, two ounces to fifty gallons of water.

(13.) Peach trees and American varieties of plums have very tender foliage, and must be treated with very weak mixtures, if at all.

(14.) Raspberries may be treated with Bordeaux mixture alone; grapes with the same until the fruit sets, after which use copper carbonate. Potatoes should be sprayed at least five times with Bordeaux mixture and Paris green.

BULLETIN

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FIELD EXPERIMENTS WITH COMMERCIAL AND OTHER FERTILIZERS IN 1892.

[By C. E. Thorne and J. Fremont Hickman.]

The general plan of these experiments has been described in previous issues of this bulletin.*

Briefly stated, a tract of uniform land is divided into plots containing one-tenth or one-twentieth acre each; the plots are 16 feet wide and are separated by alley-ways 2 feet wide. Under every second alley-way a tile drain is laid. In the case of the wheat plots the soil is clay, lying upon the bowlder clay of the drift and that upon Huron shale at a depth of 15 to 20 feet. It was formerly covered with forest, in which beech and elm predominated, and was wet and heavy before being drained. The plots on which corn and oats are grown have a gravel sub-soil, which gives partial drainage.

Twenty-two tenth-acre plots are devoted to the continuous culture each of wheat, corn and oats, each plot receiving the same treatment each year. Table 1 gives the order in which the plots are arranged, the quantity and cost per acre of fertilizer applied to each plot, and the quantity and cost per acre of essential ingredients contained. The cost is computed on the basis of the present price per ton in eastern markets, with five dollars per ton added for freight.

*Vol. III, 1890, p. 20; Vol. IV, 1891, p. 58; Vol. V, 1892, p. 35.

TABLE 1.—FERTILIZERS ON WHEAT, CORN AND OATS GROWN CONTINUOUSLY.—Quantity and cost per acre.

Plot No.	Fertilizers.	Quantity.	Essential Ingredients.			Cost.
			Nitrogen.	Phos. acid.	Potash.	
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	
1	Unfertilized..................	....	....	....	....	....
2	Superphosphate[1]................	320		50		$4 00
3	Muriate of potash................	80[4]			40[4]	2 00
4	Unfertilized..................	....	....	....	....	....
5	Nitrate of soda................	160[2]	25[2]			5 20
6	Nitrate of Soda................ Superphosphate................	160[2] 320	25[2]	50		9 20
7	Unfertilized..................	....	....	....	....	....
8	Superphosphate................ Muriate of Potash................	320 80[4]		50	40[4]	6 00
9	Nitrate of Soda................ Muriate of Potash................	160[2] 80	25[2]		40	7 20
10	Unfertilized..................	....	....	....	....	....
11	Superphosphate................ Muriate of Potash................ Nitrate of Soda................	320 80[4] 320	25[2]	50	40[4]	11 20
12	Superphosphate................ Muriate of Potash................ Nitrate of Soda................	320 80 320	50	50	40	16 40
13	Unfertilized..................	....	....	....	....	....
14	Superphosphate................ Muriate of Potash................ Nitrate of Soda................	320 80[4] 480[3]	75[3]	50	40[4]	21 60
15	Superphosphate................ Muriate of Potash................ Sulphate of Ammonia................	320 80 120	25	50	40	12 40
16	Unfertilized..................	....	....	....	....	....
17	Dissolved S. C. Rock................ Muriate of Potash................ Nitrate of Soda................	300 80[4] 160[2]	25[2]	45	40[4]	9 75
18	Thomas Slag (ground)................ Muriate of Potash................ Nitrate of Soda................	300 80[4] 160[2]	25[2]	60	40[4]	10 35
19	Unfertilized..................	....	....	....	....	....
20	Barnyard manure................	8 tons.	75	25	50	
21	Linseed oil-meal................	1000	50	20	15	12 00
22	Unfertilized..................	....	....	....	....	....

[1] Dissolved bone black.
[2] 480 and 75 pounds in 1888.
[3] 160 and 25 pounds in 1888.
[4] 160 and 80 pounds previous to 1892.

Stated in another form, plots 11, 15, 17 and 18 of this experiment each receive at the rate of 520 to 560 pounds per acre of a fertilizer containing about 5½ to 6 per cent. ammonia (ammonia being about 80 per cent. nitrogen), 8 to 9 per cent. available phosphoric acid and 7 to 7¾ per cent. potash. On plot 6 the same quantities of nitrogen and phosphoric acid are used, but by omitting the potash the percentages are changed to the equivalent of 6⅓ per cent. ammonia and 10½ per cent. phosphoric acid.

FERTILIZERS ON WHEAT GROWN CONTINUOUSLY ON THE SAME LAND.

This is the fourth successive crop of wheat grown on these plots. The field was in clover in 1887; it was drained in the spring of 1888, and the first crop was sown in the fall of that year. Immediately after a crop is removed the ground is plowed to the depth or 8 or 9 inches, and it is rolled and harrowed six or seven times between plowing and seeding, the surface being reduced to the condition of a garden and no weeds being allowed to grow.

The fertilizers are spread broadcast, just before drilling the wheat, except the nitrate of soda. This is a coarse, easily soluble salt, and to apply it all in the fall would involve the leaching away of the greater part of it before the plant could make use of it.

In 1890 it was all sown in the spring, about the middle of April. For the crop of 1891 the application was divided, half being sown in the fall and half in April. For the crop of 1892 dried blood was used in the fall at the rate of forty pounds per acre, and nitrate of soda was sown in April in quantity sufficient to bring the total application up to the desired amount.

We have not discovered that the fall application, whether of nitrate or dried blood, has been any advantage.

In the crops of 1890 and 1891 the nitrate of soda produced a very marked effect on the growth of the plant, producing a dark green, rank growth of foliage. This effect was less marked this season, possibly because of the constant rains. Where nitrate and superphosphate were used in combination the wheat lodged badly, both in 1891 and 1892. Where they were used separately the tendency to lodge was not so great, and where nitrate was used in combination with Carolina rock or Thomas slag, instead of bone superphosphate, the wheat stood fairly well.

It would seem that the nitrate and superphosphate are equally responsible for throwing the wheat down.

The effect of superphosphate in stimulating an early and heavy growth of straw has been as marked this year as in previous seasons. The superphosphate plots could be distinguished within a few weeks after seeding, and their superior growth was more and more manifest until the wheat had headed out. Before harvest good judges estimated

the increased product of grain on these plots at from five to ten bushels per acre. The result of the harvest is given in table II and III, together with those of the three preceding harvests, and the average results of the four years' experiments.

[In these and subsequent tables the increase for the fertilized plots has been calculated on the assumption that if the yields of two neighboring unfertilized plots, 1 and 4, for example, were 25 and 28 bushels, respectively, the unaided yield of the fertilized plots between, 2 and 3, would have been 26 and 27 bushels. The "average yield of unfertilized plots" is given in each table for general comparison, but is not used in calculating the increase.]

TABLE II.—FERTILIZERS ON WHEAT FOUR YEARS IN SUCCESSION.

Yield and increase of GRAIN *in bushels per acre.*

Plot No.	Fertilizers.	Yield per acre.					Increase or decrease (—) per acre.					Plot No.
		1889.	1890.	1891.	1892.	Average.	1889.	1890.	1891.	1892.	Average.	
1	None	50.5	31.9	31.8	26.2	35.1	....	....	....	....	....	1
2	Superphosphate (dissolved bone-black)	50.2	35.6	29.3	31.2	36.6	2.9	3.7	—2.6	4.7	2.2	2
3	Potash (muriate)	47.5	32.1	30.2	28.2	34.5	3.5	0.3	—1.7	1.3	0.8	3
4	None	40.8	31.8	32.0	27.2	33.0	....	....	....	....	....	4
5	Nitrate of soda (1)	40.0	36.5	33.7	27.9	34.5	—3.0	4.3	0.6	0.2	0.5	5
6	Nitrate and superphosphate (1)	40.8	38.6	31.2	28.9	34.9	—4.5	6.0	—3.0	0.8	—0.2	6
7	None	47.5	33.0	35.3	28.6	36.1	....	....	....	....	....	7
8	Superphosphate and potash	41.6	36.4	30.5	30.2	34.7	—4.7	3.6	—3.4	1.7	—0.7	8
9	Nitrate and potash (1)	45.6	36.8	33.4	29.1	36.2	0.4	4.2	0.8	0.8	1.6	9
10	None	44.0(3)	32.4	31.2	28.1	33.9	....	....	....	....	....	10
11	Superphosphate, potash and nitrate 160 (1)	49.5	36.9	28.8	29.1	36.1	5.4	5.3	—2.5	1.4	2.5	11
12	Superphosphate, potash and nitrate 320	49.3	35.7	29.7	29.2	36.0	5.2	5.0	—1.7	2.0	2.6	12
13	None	44.2	29.9	31.5	26.8	33.1	....	....	....	....	....	13
14	Superphosphate, potash and nitrate 480 (2)	47.0	34.9	28.8	29.2	35.0	4.9	4.2	—2.5	2.1	2.4	14
15	Superphosphate, potash and ammonia	47.0	33.8	29.8	30.4	35.2	7.1	2.2	—1.2	3.0	2.7	15
16	None	37.8	32.4	30.8	27.8	32.2	....	....	....	....	....	16
17	Rock phosphate, potash and nitrate (1)	40.0	37.4	33.2	31.1	35.4	1.3	5.5	2.2	4.1	3.3	17
18	Slag phosphate, potash and nitrate (1)	39.3	37.3	31.7	31.6	35.0	—0.3	5.8	0.4	5.4	2.8	18
19	None	40.5	31.0	31.5	25.4	32.1	....	....	....	....	....	19
20	Barnyard manure	44.5	34.7	27.3	25.4	33.0	5.3	5.2	—2.7	1.1	2.2	20
21	Linseed oil meal	38.7	33.9	34.7	27.5	33.7	0.7	5.9	6.1	4.2	4.3	21
22	None	36.7	26.5	27.1	22.2	28.1	....	....	....	....	....	22
	Average of unfertilized plots	42.8	31.1	31.4	26.5	33.0	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	1.7	4.4	—0.8	2.3	1.9	

(1) 480 pounds nitrate in 1889. (3) Estimated.

(2) 160 pounds nitrate in 1889.

TABLE III.—FERTILIZERS ON WHEAT FOUR YEARS IN SUCCESSION.

Yield and increase of STRAW *in pounds per acre.*

Plot No.	Fertilizers.	Yield per acre.					Increase or decrease (—) per acre.					Plot No.
		(3) 1889.	1890.	1891.	1892.	Average.	1889.	1890.	1891.	1892.	Average.	
1	None	4,070	3,602	4,540	3,015	3,807	....	....	....	....	....	1
2	Superphosphate (dissolved bone-black)	4,208	3,885	4,995	4,265	4,338	264	390	642	1,372	667	2
3	Potash (muriate)	3,850	3,062	3,740	3,190	3,461	32	—327	—427	418	— 75	3
4	None	3,692	3,282	3,980	2,650	3,401	....	....	....	....	....	4
5	Nitrate of soda (1)	3,560	3,930	3,980	2,710	3,545	—251	630	— 83	— 13	70	5
6	Nitrate and superphosphate (1)	3,512	4,385	5,330	3,830	4,264	—419	1,064	1,183	1,053	715	6
7	None	4,050	3,340	4,230	2,870	3,622	....	....	....	....	....	7
8	Superphosphate and potash	3,304	4,152	4,570	3,625	3,913	—563	703	557	778	369	8
9	Nitrate and potash (1)	4,504	3,852	4,395	2,990	3,935	821	294	598	167	470	9
10	None	3,500	3,667	3,580	2,800	3,387	....	....	....	....	....	10
11	Superphosphate, potash and nitrate 160 (1)	4,270	4,725	5,675	4,390	4,765	754	1,250	2,047	1,582	1,409	11
12	Superphosphate, potash and nitrate 320	4,262	4,835	5,965	4,360	4,855	730	1,551	2,298	1,543	1,530	12
13	None	3,548	3,092	3,710	2,825	3,294	....	....	....	....	....	13
14	Superphosphate, potash and nitrate 480 (2)	3,920	4,592	5,820	4,235	4,642	344	1,428	2,280	1,447	1,375	14
15	Superphosphate, potash and ammonia	3,920	3,720	4,660	3,860	4,040	316	485	1,290	1,108	800	15
16	None	3,632	3,307	3,200	2,715	3,213	....	....	....	....	....	16
17	Rock phosphate, potash and nitrate (1)	3,460	4,175	4,860	3,720	4,054	—153	987	1,607	1,090	883	17
18	Slag phosphate, potash and nitrate (1)	3,542	4,312	4,800	3,870	4,131	— 49	1,243	1,493	1,325	1,003	18
19	None	3,570	2,950	3,360	2,460	3.085	....	....	....	....	....	19
20	Barnyard manure	4,030	3,850	4,810	3,110	3,950	770	991	1,645	787	1,048	20
21	Linseed oil-meal	3,618	3,775	4,670	2,835	3,724	668	1,007	1,700	648	1,006	21
22	None	2,640	2,677	2,775	2,050	2,535	....	....	....	....	....	21
	Average of unfertilized plots	3,588	3,240	3,672	2,673	3,294	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	233	835	1,202	949	805	

(1) 480 pounds nitrate in 1889. (2) 160 in 1889.

(3) Corrected weight. The weights reported for "straw" in the bulletin for 1890, page 52, include total produce.

The crop of 1889 was grown on clover sod, thoroughly underdrained. The yield of the unfertilized plots averaged almost 43 bushels per acre, which is nearly three times the average yield of the state for that season (14.6 bus.) Our method of calculation shows an apparent increase of yield on plots 2 and 3, dressed with superphosphate and potash singly; but the fact that the actual yields of these plots were both smaller than plot 1, and the close agreement in subsequent years in the yields of plots 1, 4 and 7, give ground for the suspicion that the apparent increase on plots 2 and 3 this season is due wholly to an abnormally low yield in plot 4, and not to any effect of the fertilizers. This suspicion is strengthened by the low yields of plots 6, 8 and 9, on which superphosphate and potash were used in combination with each other or with nitrate of soda.

On the plots receiving a complete fertilizer, that is, one containing nitrogen, phosphoric acid and potash, all three, there seems to have been a general increase of crop. The low yields on plots 17 and 18 may possibly have been due to the slower action of the rock and slag phosphate than of the superphosphate, a surmise which is supported by the marked superiority in yield of these plots in subsequent years. This may possibly explain the small increase in plot 21, also.

Considering the results of this season's experiments as a whole, it seems that the clover sod has furnished a very large supply of available plant food in just the condition and proportion required to most effectually meet the needs of the wheat plant, and that no increase of crop beyond what the clover sod was able to produce has been obtained until a complete fertilizer was added.

In the crop of 1890 the average yield of the unfertilized plots was 31.1 bushels, the average yield of the state for that year being 11.4 bushels. This season there was apparently an increase from every application of fertilizer, the increase being generally larger where a complete fertilizer was used, but it would seem that the combination of phosphoric acid and nitrogen has been as effective in grain production as the complete fertilizer. It should be noted, however, that the straw yield apparently rises when potash is added to the combination of nitrogen and phosphoric acid.

In the crop of 1891 the average yield of the unfertilized plots was 31.4 bushels, a slight increase over the yield of 1890, although this was the third season of continuous cropping. The average yield of the state that year was estimated by the Secretary of the State Board of Agriculture in October, at 17.5 bushels, a yield surpassed only once since 1850, namely, in 1879, when it was 17.8 bushels.

The experiments of 1891 present the remarkable phenomenon of a uniform decrease in yield of grain wherever bone-black superphosphate was used. The plots receiving rock and slag phosphates show no decrease, and little or no increase. Nitrate of soda seems to have had no effect on the grain yield, whether used alone or in combination, and if potash had any effect it was unfavorable. In the case of the straw yield,

however, the very opposite effect is observed; wherever phosphoric acid was used the yield of straw was largely increased; when nitrogen was added to the phosphoric acid a still greater increase of straw was obtained, and when, in this combination, the phosphoric acid was used in the form of bone black supherphosphate the increase of straw reached a ton to the acre—straw enough to have borne nearly twenty bushels of wheat, had it carried grain in the same proportion as the straw of the unfertilized plots.

In the crop of 1892 the average yield of grain on the unfertilized plots fell to 26.5 bushels, the yield for the state at large being about half this quantity. The yield of plot 2, taken alone, would indicate a considerable increase from the use of bone-black superphosphate this year; but this indication is not supported by the yields of the other plots upon which the same superphosphate was used, hence we must conclude that the increase indicated on plot 2 is accidental. Nitrogen seems to have had little or no effect this season, and although an increase is indicated in every case where a complete fertilizer was used it is extremely small. In the case of the straw yields, a decided increase is shown wherever phosphoric acid was used, and this increase was greatest where the phosphoric acid was used in the form of bone-black superphosphate.

Considering now the four years' work as a whole, we find that no chemical fertilizer or combination of such fertilizers has, in a single instance, produced sufficient increase of grain to pay the cost of the fertilizer, except, possibly, in the case of plot 2 in 1892, a case which, as has already been stated, was probably accidental. What is much more remarkable is the fact that the fertilizers have apparently had, in many cases, a smaller effect in the fourth season of continuous cropping, the fertilizers being applied every year, than they had on the clover sod. This is shown in the case of the plot dressed with barn-yard manure, and in those of the four plots, 11, 12, 14 and 15, dressed with a complete fertilizer containing bone-black superphosphate. The average increase from these plots is collected in tables IV and V in order to give a more comprehensive view:

TABLE IV—INCREASE OF GRAIN FROM COMPLETE FERTILIZER CONTAINING BONE-BLACK SUPERPHOSPHATE.

Plot No.	Fertilizer.	Increase or Decrease (—) per acre.				
		1889.	1890.	1891.	1892.	Average.
		Bushels.	Bushels.	Bushels.	Bushels.	Bushels.
11	Chemical, complete...........	5.4	5.3	—2.5	1.4	2.5
12	" "	5.2	5.0	—1.7	2.0	2.6
14	" "	4.9	4.2	—2.5	2.1	2.4
15	" "	7.1	2 2	—1.2	3.0	2.7
20	Barn-yard manure..............	5.3	5 2	—2.7	1.1	2.2
	Average increase...........	5.6	4.4	—2.1	1.9	2.5

TABLE V—INCREASE OF STRAW FROM COMPLETE FERTILIZER CONTAINING BONE-BLACK SUPERPHOSPHATE.

Plot. No.	Fertilizers.	Increase per acre.				
		1889.	1890.	1891.	1892.	Average.
		Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
11	Chemical, complete	754	1,250	2,047	1,582	1,409
12	" "	730	1,551	2,298	1,543	1,530
14	" "	344	1,4[illegible]8	2,280	1,447	1,375
15	" "	316	485	1,2[illegible]	1,108	800
20	Barnyard manure	770	991	1,6[illegible]5	787	1,048
	Average increase	583	1,141	1,912	1,293	1,232

It would seem from tables IV and V that, by use of barnyard manure, or of a complete fertilizer containing bone-black superphosphate, the normal yield of 43 bushels per acre given by the clover sod in 1889 was increased by a larger quantity than the yield of 26½ bushels given by the same land in the fourth year of successive cropping, the same dressing of fertilizers or manure being repeated each year.

Whether the increase of crop indicated when a complete fertilizer was used on the clover sod was actually due to the fertilizer, or was only the result of irregularities in the soil, it is impossible to tell. This point is worthy of farther investigation. There seems no reason to doubt, however, that the increase indicated in 1890 was actually due to the fertilizers, and this, it will be seen, was more than double that obtained two years later from the same plots and in a much smaller average yield.

THE LODGING OF WHEAT.

The variety of wheat grown in these tests--Velvet Chaff (Penquite's)—is among those least subject to lodging of all the varieties yet tested by this Station, but it will go down sometimes. In 1889 the entire plot under experiment stood perfectly; in each of the three following years more or less of the grain went down, the relative lodging being shown in table VI:

TABLE VI—FERTILIZERS ON WHEAT THREE YEARS IN SUCCESSION.

Percentage of STRAW *lodged.*

Plot No.	Fertilizers.	1890.	1891.	1892.
1	None	....	....	....
2	Superphosphate	....	5	....
3	Muriate of potash	....	....	....
4	None	....	....	....
5	Nitrate of soda	....	20	....
6	Nitrate and superphosphate	....	80	50
7	None	....	....	....
8	Superphosphate and potash	....	5	40
9	Nitrate and potash	....	5	50
10	None	....	....	....
11	Superphosphate, potash and nitrate 160	....	100	100
12	Superphosphate, potash and nitrate 320	....	100	100
13	None	....	....	....
14	Superphosphate, potash and nitrate 480	80	100	100
15	Superphosphate, potash and ammonia	....	....	20
16	None	....	....	....
17	Rock phosphate, potash and nitrate	....	5	5
18	Slag phosphate, potash and nitrate	....	5	5
19	None	....	....	....
20	Barnyard manure	....	60	100
21	Linseed oil-meal	....	20	50
22	None	....	....	....

The increasing tendency to lodge manifested in 1891 and 1892 is probably not altogether due to the fertilizers, as the wheat grown on unfertilized land has manifested this tendency to a greater degree during these two seasons than during the two preceding; but it is plainly partly due to the fertilizers, and whether a smaller application would produce a better proportionate result is a question which cannot be satisfactorily answered until the Station has more land at its disposal for this work. The results obtained on plots 17 and 18 suggest the possibility of overcoming this tendency by the use of other fertilizing materials; but this point cannot yet be fully investigated, for the reason already given.

In table VII is given the weight of grain per measured bushel for the last three seasons, and the pounds of straw required to carry a bushel of grain for each plot for each of the four seasons:

TABLE VII—FERTILIZERS ON WHEAT, FOUR YEARS IN SUCCESSION.

Weight of GRAIN *per measured bushel, and pounds of straw to one bushel of grain.*

Plot No.	Fertilizers.	Weight per bushel.				Straw to bushel.					Plot No.
		1890.	1891.	1892.	Average.	1889.	1890.	1891.	1892.	Average.	
1	None	64¾	62½	59½	62¼	80	113	140	115	112	1
2	Superphosphate (dissolved bone-black)	64½	61	61	62¼	82	109	170	137	124	2
3	Potash (muriate)	65	61½	60½	62¼	80	95	124	113	103	3
4	None	64½	61	60½	62	90	103	124	98	104	4
5	Nitrate of soda (1)	64	62	59½	61¾	89	108	118	97	103	5
6	Nitrate and superphosphate (1)	64	61¼	59¼	61½	86	113	171	132	125	6
7	None	64½	62¾	59¼	62¼	85	101	120	100	101	7
8	Superphosphate and potash	64¼	62½	61	62½	80	114	150	120	116	8
9	Nitrate and potash (1)	64¼	61½	60	62	99	105	132	103	110	9
10	None	64	61¾	61	62¼	80	113	114	100	102	10
11	Superphosphate, potash and nitrate, 160 (2)	64¼	60	58¾	61	86	128	197	151	140	11
12	Superphosphate, potash and nitrate, 320	64½	60	58	61	86	135	192	149	140	12
13	None	63¾	61¾	60¾	62	80	104	118	106	102	13
14	Superphosphate, potash and nirate 480 (1)	62¾	60½	56¾	60	83	131	202	145	140	14
15	Superphosphate, potash and ammonia	63½	61¾	60½	62	83	110	156	127	119	15
16	None	63¾	62¾	59¾	62	96	102	104	97	100	16
17	Rock phosphate, potash and nitrate (1)	63¾	62½	60	62	86	112	146	119	116	17
18	Slag phosphate, potash and nitrate (1)	64	62½	60	62¼	90	116	151	122	120	18
19	None	64	62¾	59½	62	88	95	107	97	97	19
20	Barnyard manure	63¾	60¾	57½	60¾	90	111	176	122	125	20
21	Linseed oil-meal	63	....	58	60½	93	111	134	103	110	21
22	None	63¾	....	59¾	62	72	101	102	90	91	22
	Average of unfertilized plots	64⅛	62¼	60	62	84	104	116	100	101	

(1) 480 lbs nitrate in 1889.

(2) 160 lbs nitrate in 1889.

CO-OPERATIVE EXPERIMENTS WITH FERTILIZERS ON WHEAT.

At the time the experiment just described was begun, a similar test was started in Columbiana county, on a thin soil, derived from slaty rocks and partially drained by the cleavage of the underlying rocks.

The fertilizers were applied to plots 1 to 11, inclusive, in the same quantities as to the similarly numbered plots in the test at the Station farm, and barnyard manure was used on plot 12 in this test in duplication of plot 20 at the Station. As at the Station, nitrate of soda was used in all cases at the rate of 480 pounds per acre on the crop of 1891, but only 160 pounds per acre since. Muriate of potash was used at the rate of 160 pounds per acre in 1889 and 1890, and 80 pounds per acre in 1891. Plot 14 received common salt in 1889 instead of land plaster. Both salt and plaster have been used at the rate of 400 pounds per acre. In tables VIII and IX are given the results of this experiment for 1889, 1890 and 1891, those for 1891 not having previously been published. In 1892 the experiment was a failure, owing to the total failure of the crop. Velvet Chaff wheat was grown in this test in 1889 and 1890, and Fultz in 1891.

TABLE VIII—FERTILIZERS ON WHEAT IN COLUMBIANA COUNTY, THREE YEARS IN SUCCESSION.

Yield and increase of GRAIN *in bushels per acre.*

Plot No.	Fertilizers.	Yield per acre. 1889.	Yield per acre. 1890.	Yield per acre. 1891.	Yield per acre. Average.	Increase or decrease (—) per acre. 1889.	Increase or decrease (—) per acre. 1890.	Increase or decrease (—) per acre. 1891.	Increase or decrease (—) per acre. Average.	Plot No.
1	None	9.3	13.8	11.8	11.6	....	....	....	....	1
2	Superphosphate (dissolve bone-black)	13.3	21.0	16.2	16.8	3.7	5.1	2.8	3.8	2
3	Potash (muriate)	11.0	18.7	17.0	15.6	1.2	0.6	1.9	1.3	3
4	None	10.1	20.2	16.8	15.7	....	....	....	....	4
5	Nitrate of soda	13.3	21.5	19.8	18.2	3.4	2.3	1.5	2.4	5
6	Nitrate and superphosphate	15.0	22.2	22.1	19.8	5.3	4.0	2.4	3.9	6
7	None	9.5	17.2	21.2	16.0	....	....	....	....	7
8	Superphosphate and potash	9.3	15.8	17.5	14.2	1.1	—0.6	—1.8	—0.5	8
9	Nitrate and potash	10.5	19.0	18.8	16.1	3.4	3.4	1.3	2.7	9
10	None	6.0	14.8	15.7	12.2	....	....	....	....	10
11	Superphosphate, potash and nitrate	10.6	18.3	21.3	16.7	5.9	5.0	5.4	5.4	11
12	Barnyard manure	4.1	17.2	16.8	12.7	0.8	5.3	0.7	2.3	12
13	None	2.0	10.3	16.3	9.5	....	....	....	....	13
14	Land plaster	1.5	11.5	13.0	8.7	—0.5	1.2	—3.3	—0.8	14
	Average of unfertilized plots	7.4	15.3	16.4	13.0	....	....	....	....	

TABLE IX—FERTILIZERS ON WHEAT IN COLUMBIANA COUNTY, THREE YEARS IN SUCCESSION.

Yield and increase of STRAW *in pounds per acre.*

Plot No.	Fertilizers.	Yield per acre.				Increase or decrease (—) per acre.				Plot No.
		1889.	1890.	1891.	Average.	1889.	1890.	1891.	Average.	
1	None	1,475	2,240	1,590	1,768	....	....	....	....	1
2	Superphosphate (dissolve bone-black)	1,740	3,320	1,730	2,263	207	895	73	392	2
3	Potash (muriate)	1,540	2,920	1,770	2,077	—52	307	47	101	3
4	None	1,650	2,800	1,790	2,080	....	....	....	....	4
5	Nitrate of soda	2,140	3,940	2,370	2,817	523	1,247	473	748	5
6	Nitrate and superphosphate	2,160	4,080	2,500	2,913	577	1,493	497	855	6
7	None	1,550	2,480	2,110	2,047	....	....	....	....	7
8	Superphosphate and potash	1,300	2,520	1,790	1,870	—127	213	—237	—50	8
9	Nitrate and potash	1,665	3,300	2,210	2,392	362	1,167	267	598	9
10	None	1,180	1,960	1,860	1,667	....	....	....	....	10
11	Superphosphate, potash and nitrate	1,560	3,000	2,360	2,307	580	1,193	587	787	11
12	Barnyard manure	945	2,300	2,060	1,768	165	647	373	395	12
13	None	580	1,500	1,600	1,227	....	....	....	....	13
14	Land plaster	495	1,480	1,720	1,232	—95	—20	120	5	14
	Average of unfertilized plots	1,287	2,196	1,790	1,758	....	....	....	....	

The tables show that although the average yield of this land is only about half as great as that on which the experiments at the Station are conducted, yet the increase from fertilizers has been practically no greater in Columbiana than in Franklin county, except that in 1891 the superphosphate seems to have produced a slight gain in Columbiana, instead of a loss, as in Franklin.

FERTILIZERS ON CROPS GROWN IN ROTATION.

Parallel with the experiments in continuous cropping an experiment has been conducted on the Columbus farm in which wheat is grown in rotation with other crops. In this experiment five blocks of land, each block containing seven plots of one-twentieth acre each, are cultivated in wheat, clover, timothy, corn and oats, the cropping being so managed that each crop is represented each year.

Following is the plan of fertilizing each block:

Plot 1. Unfertilized.

Plot 2. Superphosphate, 300 pounds per acre; muriate of potash, 80 pounds per acre,* on corn only.

Plot 3. Superphosphate, 300 pounds per acre; muriate of potash, 80 pounds per acre,* on wheat only.

Plot 4. Unfertilized.

Plot 5. Superphosphate, 300 pounds per acre; muriate of potash, 80 pounds per acre;* nitrate of soda, 160 pounds per acre, on wheat only.

Plot 6. Barnyarnd manure, 8 tons per acre, on wheat only.

Plot 7. Unfertilized.

*160 pounds, previous to 1892.

Table X shows the yields for 1892 of the crops of wheat, clover, timothy and oats grown in this rotation; the corn crop has not yet come under the rotation.

TABLE X—FERTILIZERS ON CROPS GROWN IN ROTATION, 1892.

Yield and increase per acre.

Wheat—Block C.					Clover—Block A.			Oats—Block D.			Value of increase.‡
Grain.			Straw.					Grain.			
Plot No.	Yield.	Increase.	Yield.	Increase.	Plot No.	Yield.	Increase.	Plot No.	Yield.	Increase.	
	Bush.	*Bush.*	*Pounds.*	*Pounds*		*Pounds.*	*Pounds*		*Bush.*	*Bush.*	*Dols.*
1	34.2	....	3,530	....	25	†............	....	8	29.2	....	....
2	32.4	0.1	3,040	*—220	26	5,000	....	9	37.3	6.7	2.08
3	35.7	5.4	3,440	477	27	5,000	40	10	33.0	1.1	4.82
4	28.4	....	2,680	....	28	4,920	....	11	33.3	....	....
5	35.6	6.7	3,550	963	29	5,200	360	12	35.8	3.1	8.47
6	28.4	*—0.9	2,980	487	30	5,120	360	13	27.7	*—4.3	.23
7	29.7	....	2,520	....	31	4,680	....	14	31.4	....	....

*Decrease. †The clover on part of this plot was destroyed by accident, hence it is not included in the test of this year. ‡The value of increase is computed on the basis of the following prices: Wheat, 70 cents per bushel; straw, $2.00 per ton; hay, $10.00 per ton; oats, 33 cents per bushel.

It will be observed that the apparent increase of grain from the superphosphate is greater in this rotated wheat than in that grown continuously, and that the fertilizers have apparently expended the greater part of their strength on the crops to which they were applied, leaving but little surplus for the following crops.

We cannot say that the case might not be different were the phosphoric acid applied in a form not so quickly available as superphosphate, such as bone meal or basic slag.

The average yield of the unfertilized plots in this rotation is 30.8 bushels per acre; that of the unfertilized plots where wheat is grown continuously is 26.5 bushels for the same season, 1892,—a difference almost as great as any produced by fertilizers. Moreover, the wheat grown in rotation stood almost perfectly, the only patch of lodged grain being a small part of plot 1.

In table XI is given the average yield of grain and straw and the average number of pounds of straw required to produce a bushel of grain under continuous as compared with rotative cropping for the two seasons, 1891 and 1892; the treatment being alike in other respects:

TABLE XI—CONTINUOUS, COMPARED WITH ROTATIVE CROPPING OF WHEAT.

Average results for two seasons.

Fertilizers.	Yield per acre.				Straw to one bushel.	
	Grain.		Straw.			
	Continuous.	Rotative.	Continuous.	Rotative.	Continuous.	Rotative.
	Bushels	*Bushels*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
None	29.0	34.0	3,172	3,655	109	107
Superphosphate and potash	30.3	35.9	4,122	4,635	136	129
Superphosphate, potash & nitrate	28.9	35.9	5,032	4,835	174	135
Barnyard manure	26.3	33.2	3,960	3,750	150	113

This table shows that the rotation employed in this experiment has added from five to seven bushels to the crop of wheat, the treatment being similar in other respects, and it shows that, while the actual produce of straw, in the absence of nitrogenous fertilizers, has been greater under rotative than under continuous cropping, yet it has invariably required less straw to carry a bushel of grain under rotation, the treatment being otherwise the same.

FERTILZERS ON OATS GROWN CONTINUOUSLY ON THE SAME LAND.

Adjoining the section devoted to the continuous culture of wheat is another of the same size on which oats have been grown continuously for four seasons.

The soil of this section differs from that on which wheat is grown in being underlaid with gravel, which gives partial drainage. This drainage has been supplemented, however, by tiles, laid on the same plan as under the wheat plots.

The plan of fertilizing is the same for the oats as for the wheat, except that in 1892 dried blood, at the rate of 160 pounds per acre, was substituted for the large dressing of nitrate of soda on plot 14, the experience of the three preceding seasons having shown that such excessive applications invariably cause the oats to lodge and thus reduce the yield.

Tables XII and XIII give the yield and increase of grain and straw for each of the four seasons, 1889 to 1892, and the average yield and increase for the entire period.

TABLE XII—FERTILIZERS ON OATS, FOUR YEARS IN SUCCESSION.

Yield and increase of GRAIN *in bushels of 32 pounds.*

Plot No.	Fertilizers.	Yield per acre. 1889.	1890.	1891.	1892.	Average	Increase or decrease (—) per acre. 1889.	1890.	1891.	1892.	Average	Plot No.
1	None	44.2	16.0	......	......	......	......	......	......	......	......	1
2	Superphosphate (dissolved bone black)	46.9	19.4	46.6	29.4	35.6	1.4	3.4	6.4	0.6	2.3	2
3	Potash (muriate)	59.5	19.7	45.9	32.5	39.4	12.6	3.7	5.7	3.7	6.1	3
4	None	48.2	16.0	40.2	28.8	33.3	......	......	......	......	......	4
5	Nitrate of soda	47.2	21.1	45.6	32.7	36.6	0.1	3.9	5.3	5.4	3.6	5
6	Nitrate and superphosphate	48.4	22.3	51.2	32.2	38.5	2.3	3.8	10.7	6.4	5.8	6
7	None	45.0	19.7	40.6	24.3	32.4	......	......	......	......	......	7
8	Superphosphate and potash	45.0	21.6	46.6	32.2	36.3	—0.8	2.3	4.3	4.5	2.5	8
9	Nitrate and potash	48.4	23.7	46.6	40.3	39.7	1.8	4.9	2.7	9.3	4.6	9
10	None	47.5	18.4	45.6	34.4	36.5	......	......	......	......	......	10
11	Superphosphate, potash and nitrate, 160	52.9	24.7	50.9	40.9	42.3	5.6	7.4	6.0	3.6	5.6	11
12	Superphosphate, potash and nitrate, 320	47 8	25.3	52.3	43.1	42.1	0.8	9.0	8.2	3.0	5.2	12
13	None	46.8	15.2	43.4	43.0	37.1	......	......	......	......	......	13
14	Superphosphate, potash and nitrate. 480*	45.0	20.8	48.4	43.3	39.4	1.6	4.3	3.9	2.1	3.0	14
15	Superphosphate, potash and ammonia	51.8	23.9	49.4	40.1	41.3	11.9	6.0	3.9	0.8	5.6	15
16	None	36.5	19.2	46.6	37.5	34.9	......	......	......	......	......	16
17	Rock phosphate, potash and nitrate	47.3	21.6	49.7	41.1	39.9	10.3	4.0	3.7	4.0	5.5	17
18	Slag phosphate, potash, and nitrate	45.7	22.8	51.6	43.6	40.9	8.4	6.7	6.3	6.8	7.0	18
19	None	37.9	14.5	44.7	36.4	33.4	......	......	......	......	......	19
20	Barnyard manure	42.8	19.1	50.3	36.9	37.3	2.2	3.3	5.6	0.5	2.9	20
21	Linseed-oil meal	50.6	14.8	46.7	25.8	34.5	7.2	—2.3	2.0	—10.6	1.1	21
22	None	46.1	18.4	......	......	......	......	......	......	......	......	22
	Average of unfertilized plots	44.0	17.2	42.8	34.1	34.6	......	......	......	......	......	
	Average increase from fertilizers	......	......	......	......	......	4.7	4.5	5.3	2.9	4.3	

*Dried blood 160 pounds, instead of nitrate in 1892.

TABLE XIII—FERTILIZERS ON OATS, FOUR YEARS IN SUCCESSION.

Yield and increase of STRAW *in pounds per acre.*

Plot No.	Fertilizers.	Yield. 1889.	Yield. 1890.	Yield. 1891.	Yield. 1892.	Yield. Average	Increase or decrease (—). 1889.	Increase or decrease (—). 1890.	Increase or decrease (—). 1891.	Increase or decrease (—). 1892.	Increase or decrease (—). Average	Plot No.
1	None	3,180	1,900	....	....	....	....	....	....	....	....	1
2	Superphosphate	3,520	2,370	3,310	2,960	3,040	133	343	845	180	375	2
3	Muriate potash	4,220	2,270	2,680	3,1[illegible]0	3,082	627	317	215	380	385	3
4	None	3,800	1,980	2,465	2,780	2,756	....	....	....	....	....	4
5	Nitrate soda	3,980	2,680	2,540	3,155	3,089	233	653	100	478	441	5
6	Superphosphate and nitrate	4,068	2,900	2,160	3,020	3,037	375	827	—260	445	346	6
7	None	3,640	2,120	2,400	2,472	2,658	....	....	....	....	....	7
8	Superphosphate and potash	3,660	2,580	2,910	3,170	3,080	—87	300	480	539	296	8
9	Potash and nitrate	4,040	3,070	2,810	2,960	3,220	197	630	250	169	311	9
10	None	4,960	2,600	2,640	2,950	3,037	....	....	....	....	....	10
11	Superphosphate, potash and nitrate, 160	4,400	3,210	2,620	2,940	3,292	487	587	5	—68	253	11
12	Superphosphate, potash and nitrate, 320	4,300	3,320	2,875	3,020	3,379	433	673	290	—47	337	12
13	None	3,820	2,670	2,560	3,125	3,044	....	....	....	....	....	13
14	Superphosphate, potash and nitrate, 480*	3,880	2,930	2,550	3,665	3,256	267	450	57	732	376	14
15	Superphosphate, potash and ammonia	3,060	3,270	2,670	2,965	3,241	653	980	243	223	525	15
16	None	3,200	2,100	2,360	2,550	2,552	....	....	....	....	....	16
17	Rock phosphate, potash and nitrate	3,800	2,910	2,110	3,435	3,064	647	860	—120	640	507	17
18	Slag phosphat , potash and nitrate	3,500	3,120	2,200	3,205	3,006	363	1,120	100	165	444	18
19	None	3,060	1,950	1,970	3,285	2,566	....	....	....	....	....	19
20	Barnyard manure	3,140	2,650	2,540	3,420	2,937	—167	450	570	143	249	20
21	Linseed oil meal	4,100	2,470	2,215	3,675	3,115	547	20	245	407	305	21
22	None	3,800	2,700	....	3,260	....	....	....	....	....	....	22
	Average of unfertilized plots	3,557	2,252	2,400	2,917	2,768	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	338	586	212	313	362	

*Dried blood, 160 lbs., instead of nitrate in 1892.

It appears from this table that in the case of oats there has been a constant increase of grain following the use of fertilizers, the only case where there was any marked falling off in the yield of grain being on the plot where oil meal was used, and this may be explained by the early lodging of the oats on this plot.

It appears that each of the three fertilizing materials used—superphosphate, muriate of potash and nitrate of soda—has in nearly every case produced an increase of crop. It would seem that potash is having a more favorable effect upon the oats than upon the wheat, and it seems that the combination of nitrogen with either phosphoric acid or potash has on the average produced a larger increase than that following the separate use of either of the three materials, but no single fertilizer, nor no combination of fertilizers, has produced an increase in the average crop sufficient to pay the cost of the fertilizer.

In the case of the oats straw it will be observed that, while there is a general increase of straw following the use of the fertilizers, this increase is usually much smaller than in the case of wheat.

FERTILIZERS ON CORN GROWN CONTINUOUSLY ON THE SAME LAND.

The section devoted to fertilizer experiments with corn grown continuously on the same land at the Columbus farm lies immediately north of that devoted to similiar experiments with oats, and the plots of the same number are continuous through both sections, being crossed by a narrow roadway which separates the sections. The soil of both sections lies over gravel, the gravel being a little nearer the surface (within three to five feet) under the corn than under the oats. As there are areas where the gravel drainage is not perfect it has been supplemented by tile drains, laid 36 feet apart.

Five successive crops of corn have been grown on this land, and the results are given in tables XIV and XV.

TABLE XIV—FERTILIZERS ON CORN, FIVE YEARS IN SUCCESSION.

Yield and increase of GRAIN *in bushels of 70 pounds of ears.*

Plot No.	Fertilizer.	Yield per acre. 1888.	1889.	1890.	1891.	1892.	Aver'ge.	Increase or decrease (—) per acre. 1888.	1889.	1890.	1891.	1892.	Av'ge.	Plot No.
1	None	86.0	64.6	51.3	56.4	66.3	64.9	....	....	....	....	....	....	1
2	Superphosphate (disolved bone black)	83.0	65.0	49.4	61.1	61.4	64.0	—5.7	—0.8	—2.0	4.1	—3.9	—1.6	2
3	Potash (muriate)	89.4	60.0	50.3	61.7	65.7	65.4	—2.1	—7.1	—1.2	4.0	1.4	—1.0	3
4	None	94.2	68.3	51.6	58.3	63.3	67.1	....	....	....	....	....	....	4
5	Nitrate of soda	91.4	67.7	50.4	68.1	74.9	70.5	—2.4	2.4	1.3	9.8	11.1	4.4	5
6	Nitrate and superphosphate	96.8	68.9	50.3	69.7	73.6	71.9	3.4	6.6	3.7	11.5	9.3	6.9	6
7	None	93.0	59.3	44.1	58.2	64.7	63.9	....	....	....	....	....	....	7
8	Superphosphate and potash	89.5	63.7	48.4	54.2	74.0	66.0	—3.2	3.8	3.2	—4.4	8.9	1.7	8
9	Nitrate and potash	93.1	67.6	53.9	68.0	76.4	71.8	0.7	7.1	7.6	9.0	10.9	7.1	9
10	None	92.1	61.1	47.4	59.4	66.0	65.2	....	....	....	....	....	....	10
11	Superphosphate,potash and nitrate,160	85.7	71.1	50.5	69.5	76.0	70.6	—5.9	7.8	2.9	10.0	9.3	4.8	11
12	Superphosphate,potash and nitrate 320	93.7	63.9	54.1	71.6	77.4	72.1	2.7	—1.6	6.2	12.0	9.9	5.8	12
13	None	90.5	67.7	48.1	59.7	68.3	66.9	....	....	....	....	....	....	13
14	Superphosphate,potash and nitrate,480	89.2	61.4	50.3	68.2	79.9	69.8	—0.3	—2.6	3.7	11.6	13.9	5.2	14
15	Superphosphate,potash and ammonia	88.0	57.4	45.7	65.6	69.6	65.3	—0.4	—3.0	0.6	12.1	5.8	3.1	15
16	None	87.4	56.7	43.6	50.4	61.4	59.9	....	....	....	....	....	....	16
17	Rock phosphate, potash and nitrate	89.2	57.3	47.8	67.1	76.0	67.5	4.7	1.0	5.4	16.3	13.4	8.2	17
18	Slag phosphate, potash and nitrate	89.4	61.0	47.5	63.2	75.0	67.2	7.9	5.2	6.5	11.5	11.3	8.5	18
19	None	78.6	55.4	39.9	52.3	64.9	58.2	....	....	....	....	....	....	19
20	Barnyard manure	93.9	66.4	45.1	62.7	70.3	67.7	8.2	9.0	2.9	6.7	4.2	6.2	20
21	Linseed oil meal	105.2	72.6	46.2	70.2	73.7	73.6	12.3	13.3	1.6	10.5	6.4	8.8	21
22	None	100.0	61.3	47.0	63.4	68.6	68.1	....	....	....	....	....	....	22
	Average of unfertilized plots	90.2	61.8	46.6	57.3	65.4	64.3	....	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	....	1.4	2.9	3.0	8.9	8.0	4.9	

TABLE XV—FERTILIZERS ON CORN, FIVE YEARS IN SUCCESSION.

Yield and increase of STALKS* *in pounds per acre.*

Plot No.	Fertilizers.	Yield per acre. 1888.	1889.	1890.	1891.	1892.	Aver'ge.	Increase or decrease (—) per acre. 1888.	1889.	1890.	1891.	1892.	Av'ge.	Plot No.
1	None	7,600	3,472	2,436	3,640	3,420	4,114	....	....	....	....	....	....	1
2	Superphosphate (disolved bone black)	6,195	3,276	2,514	3,520	3,390	3,779	—937	—227	56	—73	—247	—286	2
3	Potash (muriate)	7,255	3,390	3,246	3,800	4,500	4,438	592	—143	765	253	647	423	3
4	None	6,195	3,564	2,503	3,500	4,070	3,966	....	....	....	....	....	....	4
5	Nitrate of soda	8,256	3,788	2,932	4,260	4,950	4,837	1,896	265	437	737	870	841	5
6	Nitrate and superphosphate	7,171	3,604	2,790	4,350	5,300	4,643	647	122	302	804	1,210	614	6
7	None	6,689	3,441	2,480	3,570	4,100	4,056	....	....	....	....	....	....	7
8	Superphosphate and potash	6,661	3,762	2,780	3,930	4,720	4,371	—222	210	367	413	703	295	8
9	Nitrate and potash	7,805	4,101	3,040	4,020	5,210	4,835	728	438	694	557	1,277	738	9
10	None	7,271	3,774	2,280	3,410	3,850	4,117	....	....	....	....	....	....	10
11	Superphos., potash and nitrate, 160	6,959	3,488	2,966	4,190	4,930	4,507	—308	—253	624	693	1,053	362	11
12	Superphos., potash and nitrate, 320	6,456	4,028	2,857	4,200	5,350	4,578	—808	320	454	617	1,447	406	12
13	None	7,260	3,675	2,465	3,670	3,930	4,200	....	....	....	....	....	....	13
14	Superphos., potash and nitrate, 480	7,087	3,660	3,141	4,040	5,400	4,666	378	296	714	600	1,670	732	14
15	Superphosphate, potash and ammonia	7,475	3,270	3,276	**........	4,850	4,718	1,318	216	886	....	1,320	935	15
16	None	5,606	2,743	2,352	2,980	3,330	3,402	....	....	....	....	....	....	16
17	Rock phosphate, potash and nitrate	7,235	3,780	2,781	3,900	4,660	4,471	1,318	962	411	924	1,273	978	17
18	Slag phosphate, potash and nitrate	6,670	3,392	2,903	3,720	4,700	4,277	443	500	516	747	1,267	695	18
19	None	6,538	2,968	2,405	2,970	3,500	3,676	....	....	....	....	....	....	19
20	Barnyard manure	5,866	3,519	2,802	3,880	3,930	4,000	—693	506	230	927	413	277	20
21	Linseed oil meal	7,573	3,830	3,304	3,840	4,950	4,700	993	772	565	903	1,417	931	21
22	None	6,601	3,103	2,906	2,920	3,550	3,816	....	....	....	....	....	....	22
	Average of unfertilized plots	6,720	3,342	2,478	3,333	3,720	3,919	....	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	....	382	285	541	579	929	....	

* Stalks and leaves the corn being cut about four inches above the ground.
** Stalks burned by trespassers.

Considering tables XIV and XV, it appears that there has been a loss of crop in four seasons out of five on the plot dressed with superphosphate alone, and in three of the five seasons on the plot treated with potash alone, while the plot on which these two substances have been used together shows practically no gain in the average of the five seasons. It seems quite clear that, in this series of experiments, superphosphate and potash have added nothing to the crop of grain, and but little to the growth of stalks, until combined with nitrogen.

The plot dressed with nitrate of soda shows a small gain in every season except the first, and that dressed with nitrate and superphosphate shows an increase every year, the average gain for the five seasons amounting nearly to seven bushels, a gain which is not increased by the addition of potash. Practically the same increase is shown by the combination of nitrate and potash, however, without any superphosphate, hence we must conclude that nitrogen is the controlling factor in producing an increase of the corn crop on this soil.

It will be observed that in the case of the corn the fertilizers seem to be having a greater effect during the later years of the experiment, and this appears to be due, not to the exhaustion of the unfertilized plots—for their average yield in the fifth season of the test was greater than for any other season except the first, and for the fourth season it was but little behind that of the second—but to a gradual accumulation of available plant food in the fertilized plots. It is interesting to note that the yield of plot 14, receiving 880 pounds per acre of a complete fertilizer, 480 pounds of which was nitrate of soda, reached a total yield of almost eighty bushels of shelled corn per acre in 1892, although this is still ten bushels below the average yield of the unaided clover sod in 1888.

It will be observed that, even in those seasons when the effect of the fertilizers was most strongly marked, it has in most cases required a dollar's worth of fertilizer, or more, to produce a bushel of increase in the crop.

Of the various complete fertilizers used, the one containing Carolina rock as the source of phosphoric acid has produced the largest average increase of corn in proportion to cost of fertilizer.

FERTILIZERS ON CORN IN WAYNE COUNTY

It is designed to continue the study of soils and fertilizers at the new home of the Station in Wayne county, and it is hoped that the larger area of land at our disposal may enable us to investigate some points more in detail than has been possible hitherto. The use of fertilizers on crops grown in rotation will hereafter occupy a leading position in these investigations, although wheat, oats and corn will still be grown in continuous culture.

The work in the continuous culture of corn is the only branch of this investigation that it was possible to start in 1892. The land selected for this work was a piece of "run out" grass land, originally seeded with clover and timothy, but which had not been cultivated for several years, and the grass had been replaced by plantain and other weeds in many places. It is considered one of the poorest fields on the Station farm. Table XVI gives the plan of the experiment, with the results for 1892. The number following the name of each fertilizer indicates the number of pounds used per acre. It will be observed that, as a rule, the fertilizers are used in smaller quantities in this test than in those heretofore described, although certain plots are fertilized to the full amount for comparison.

TABLE XVI—FERTILIZERS ON CORN IN WAYNE COUNTY, 1892.

Yield and increase of GRAIN, *per acre, in bushels of 70 pounds ears.*

Plot No.	Fertilizers per Acre.	Yield.		Increase or decrease (—)	
		Grain	Stalks	Grain	Stalks
		Bush'ls	*Pounds*	*Bush'ls*	*Pounds*
1	None	49.1	2,100	....	....
2	Superphosphate, (dissolved bone black) 160	59.9	2,420	12.5	363
3	Potash, (muriate) 100	52.0	2,290	6.4	277
4	None	43.9	1,970	....	....
5	Nitrate of soda, 160	32.0	1,790	—9.6	—143
6	Nitrate, 160; superphosphate, 160	42.9	1,860	3.6	— 37
7	None	37.0	1,860	....	....
8	Superphosphate, 160; potash, 100	58.3	2,400	22.2	517
9	Nitrate, 160; potash, 100	42.4	2,080	7.2	137
10	None	34.3	1,930	....	....
11	Superphosphate, 160; potash, 100; nitrate, 160	51.9	2,420	14.7	440
12	Superphosphate, 160; potash, 100; nitrate, 320	56.9	2,620	16.9	590
13	None	42.9	2,080	....	....
14	Superphosphate, 160; potash, 100; nitrate, 480	49.6	2,390	8.8	360
15	Superphosphate, 320; potash, 100; nitrate, 160	55.4	2,400	16.9	420
16	None	36.4	1,930	....	....
17	Superphosphate, 160; potash, 50; nitrate, 160	54.0	2,370	14.2	390
18	Superphosphate, 160; potash, 10; nitrate, 80	59.1	2,440	16.0	410
19	None	46.4	2,080	....	....
20	Open yard manure, 5 tons	53.7	2,380	7.5	257
21	Covered yard manure, 5 tons	51.7	2,320	5.8	153
22	None	45.7	2,210	....	....
23	Superphosphate, 160; dried blood, 80	50.4	2,340	4.9	157
24	Superphosphate, 160; sulphate ammonia, 64	58.9	2,640	13.4	483
25	None	45.3	2,130	....	....
26	Carolina rock, 160; nitrate, 80	54.9	2,390	11.3	243
27	Basic slag, 140; nitrate, 80	46.3	2,070	2.7	—160
28	None	40.1	2,280	....	....
	Average of unfertilized plots	42.1	2,057	....	....
	Average increase from fertilizers	....	....	9.7	261

The results shown in table XVI indicate that phosphoric acid was the most important factor in a fertilizer for corn on this land in the season of 1892, for wherever superphosphate was used there is an increase of crop. Potash seems to have come next to superphosphate in increasing the yield, but nitrogen seems to have had little or no effect, whether carried to the crop in nitrate of soda, dried blood, or sulphate of ammonia. In-

deed, there is a considerable loss of crop indicated on plot 5, where nitrate of soda was used alone, but this may have been due to variations in the soil.

It was not possible to drain this land before beginning the experiment, and thus the irregularities due to unequal drainage have much to do with the irregularities in yield shown in the table, and this source of error was greatly aggravated by the excessive rainfall of May and June. At Wooster there were 21 rainy days in June, with a total precipitation of 15.58 inches, nearly evenly divided between the two months, whereas the average rainfall for ten years during these two months in this section of the State is but 8.46 inches, 4.37 inches for May and 4.09 inches for June. Under such conditions it is not surprising that so easily soluble a salt as nitrate of soda should have failed to produce any increase of crop. It was probably all washed out of reach of the corn roots at the very beginning of the season.

There were as many rainy days in May and June at Columbus as at Wooster but the total rainfall at the University farm was but 11.36 inches, while the ten-year average for that section of the State is 8.58 inches, so that the excess of precipitation amounted to 84 per cent. of the ten-year average at Wooster, and only 32 per cent. of that average at the Station farm at Columbus. This is probably one reason why the nitrate has made so much better showing in the experiment at Columbus than in that at Wooster.

CO-OPERATIVE EXPERIMENTS WITH FERTILIZERS ON CORN.

Co-orperative experiments with fertilizers on corn were made in 1892 by H. Y. Bentley in Columbiana county, Orlando Trotter in Washington county and B. H. Brown in Butler county, thus representing the extreme eastern, south-eastern and south-western parts of the State. Tables XVII to XXI give the plan and results of these experiments, the superphosphate being in all cases dissolved bone black and used at the rate of 320 pounds per acre, the muriate of potash being used at the rate of 80 pounds per acre in 1891 and '92, and 160 pounds per acre previous to 1891; the nitrate of soda at the rate of 160 pounds per acre, the barnyard manure at the rate of 8 tons per acre and the land plaster at the rate of 400 pounds per acre.

FARM TEST IN COLUMBIANA COUNTY.

Made by H. Y. Bentley.

This test has been repeated five years in succession on the same land and under the personal superintendence of the agriculturist of the Station. The land is high upland and underlaid with slaty rocks, which give partial drainage. Previous to 1888 it had been in pasture for several years, but the growth of grass (chiefly blue grass) had become quite uneven. Tables XVII and XVIII give the yield of grain and stalks for the five years:

TABLE XVII—FERTILIZERS ON CORN IN COLUMBIANA COUNTY.

Yield and increase of GRAIN *in bushels of 70 lbs. ears.*

Plot No.	Fertilizers.	Yield per acre. 1888.	1889.	1890.	1891.	1892.	Av'age.	Increase or decrease (—) per acre. 1888.	1889.	1890.	1891.	1892.	Avg'r.	Plot No.
1	None	35.5	52·9	20.4	21.3	16.0	29.2	....	....	....	....	....	....	1
2	Superphosphate	35.9	56.4	18.3	22.4	15.7	29.7	—2.3	1.8	—2.6	—2.0	—2.1	—1.5	2
3	Muriate of potash	39.4	56.2	19.5	27.3	18.1	32.1	—1.6	0	—1.8	—0.3	—1.8	—1.1	3
4	None	43.7	57.9	21.8	30.7	21.3	35.1	....	....	....	....	....	....	4
5	Nitrate of soda	70.8	58.5	30.2	38.2	26.5	44.8	18.1	—2.0	8.1	6.4	5.1	7.1	5
6	Nitrate and supurphosphate	90.0	62.2	30.1	37.5	23.8	48.7	28.4	—1.0	7.6	4.5	2.2	8.3	6
7	None	70·6	65.8	22.8	34.1	21.7	43.0	....	....	....	....	....	....	7
8	Superphosphate and potash	70.6	62.8	14.9	23.7	15.9	37.6	—0.1	—1.8	—8.1	—8.8	—6.1	—5.0	8
9	Nitrate and potash	90.4	67.0	31.7	39.0	26.5	50.9	20.0	3.6	8.4	8.1	4.1	8.8	9
10	None	70.2	62.2	23.5	29.3	22.7	41.6	....	....	....	....	....	....	10
11	Supurphos, potash and nitrate	74.8	66.1	24.9	31.9	24.3	44.4	7.7	5.4	1.4	2.7	2.5	4.0	11
12	Barnyard manure	61.8	73.8	30.6	28.5	22.7	43.5	—2-1	14.5	7.0	—0.7	2.4	4.2	12
13	None	60.8	57.8	23.6	29.1	19.1	38.1	....	....	....	....	....	....	13
14	Land plaster	60.0	59.9	20.5	23.5	15.4	35.9	—0.8	—2.1	—3.1	—5.6	—3.7	—2.2	14
	Average of unfertilized plots	56.2	59.3	22.5	28.9	20.2	37.4	....	....	....	....	....	....	
	Average increase from fertilizers	....	....	....	....	....	....	7.5	2.5	1.9	0.5	0.3	....	

TABLE XVIII.—FERTILIZERS ON CORN IN COLUMBIANA COUNTY.

Yield and increase of STALKS, *in pounds, per acre.*

Plot No.	Fertilizers.	Yield per Acre. 1888	1889	1890	1891	1892	Aver'ge.	Increase or Decrease (—) per Acre. 1888	1889	1890	1891	1892	Av'ge.	Plot No.
1	None	4,520	2,797	1,914	2,170	2,285	2.738	....	....	....	....	....	....	1
2	Superphosphate	4,640	2,778	2,064	2,592	2,175	2,850	37	— 82	246	372	—139	87	2
3	Muriate of potash	5,050	3,001	2,125	2,934	2,282	3,078	363	77	402	663	— 60	289	3
4	None	4,770	2,987	1,627	2,321	2,371	2,815	....	....	....	....	....	....	4
5	Nitrate of soda	5,800	3,030	2,585	2,868	2,531	3,363	1,093	— 55	869	421	169	500	5
6	Nitrate and superphosphate	6,030	3,167	2,555	3,180	2,406	3,468	1,387	— 15	751	607	53	557	6
7	None	4,580	3,280	1,893	2,699	2,344	2,959	....	....	....	....	....	....	7
8	Superphosphate and potash	5,390	3,502	2,417	3,833	2,153	3,459	683	253	481	1,111	—209	464	8
9	Nitrate and potash	6,590	3,549	2,762	3,192	2 607	3,740	1,757	330	783	446	228	709	9
10	None	4,960	3,188	2,022	2,770	2,397	3,067	....	....	....	....	....	....	10
11	Superphophate potash and nitrate	6,500	3,346	2,285	3,188	2,538	3,571	1,350	210	461	393	186	520	11
12	Barnyard manure	5,140	3,757	2,595	3,828	2,474	3,559	—200	673	969	1,009	168	524	12
13	None	5,530	3,032	1,428	2,844	2,261	3,019	....	....	....	....	....	....	13
14	Land Plaster	5,810	3,028	1,520	2,480	2,080	2,984	280	— 4	92	—364	—181	— 35	14
	Average of unfertilized plots	4,872	3,057	1,777	2,561	2,332	2,920							

From these tables it appears that the use of superphosphate and potash, either singly or in combination with each other, but without nitrogen, has been followed by a decrease in yield of grain in every year except one, and in thirteen out of fifteen tests, although there has usually been an increase in yield of stalks. On the other hand, the use of nitrate of soda, either alone or combined with phosphoric acid or potash, one or both, has been followed by an increase in crop, both in grain and stalks, in every year but one, and in eighteen out of twenty tests. It appears, therefore, that, next to climatic conditions, nitrogen is the controlling factor in determining the yield of corn on this land. In this respect the results of this experiment are in close accord with those of the experiment at Columbus. In both experiments there has been an absolute loss on plots 2 and 3, while the small gain indicated in the average on plot 8 at Columbus amounts to nothing.

But the most surprising feature of these experiments is that while the effect of the fertilizers is evidently increasing at Columbus, it is as evidently decreasing in the Columbiana county test, although the average unfertilized yield at Columbus, since the second year of the test, has been twice or three times that in Columbiana county, and in 1892 the average increase over the unfertilized yield of sixty-five bushels per acre at Columbus was from two to four times as great as that on the similarly treated plots in Columbiana county, where the unfertilized yield was but twenty bushels per acre.

FARM TEST IN BUTLER COUNTY

Made by B. H. Brown.

Mr. B. H. Brown, of Oxford, Butler county, has made this experiment in 1889, 1891 and 1892, but each time on fresh ground, the test of 1889 being made on wheat stubble, and those of 1891 and 1892 on timothy sod. The land was selected because of its lack of natural fertility, the soil being a heavy clay of drift origin. Tables XIX and XX give the results of the three crops:

TABLE XIX—FERTILIZERS ON CORN IN BUTLER COUNTY.

Yield and increase of GRAIN *in bushels of 70 pounds of ears.*

Plot No.	Fertilizers.	Yield per acre. 1889.	1891.	1892.	Average.	Increase per acre. 1889.	1891.	1892.	Average.	Plot No.
1	None	18.3	21.4	42.6	27.4	......	......	......	......	1
2	Superphosphate.	35.9	39.6	42.9	39.5	15.1	15.4	0.3	10.3	2
3	Muriate of potash	41.7	32.3	62.1	45.4	18.3	5.3	19.5	14.4	3
4	None	25.9	29.9	42.6	32.8	......	......	......	......	4
5	Nitrate of soda	26.7	41.4	51.3	39.8	0.2	12.2	8.8	7.0	5
6	Nitrate and superphosphate	35.7	41.6	52.1	43.1	8.6	13.0	9.6	10.4	6
7	None	27.7	27.9	42.4	32.7	......	......	......	......	7
8	Superphosphate and potash	49.9	37.5	51.0	46.2	23.7	8.7	9.5	13.9	8
9	Nitrate and potash	37.9	47.7	51.4	45.7	13.1	18.1	10.3	13.8	9
10	None	23.3	30.5	40.9	31.6	......	......	......	......	10
11	Superphosphate, potash and nitrate	48.0	51.4	45.9	48.4	22.7	22.6	4.4	16.5	11
12	Barnyard manure	67.4	60.7	60.7	62.9	40.0	33.6	18.7	30.7	12
13	None	29.4	25.4	42.6	32.5	......	......	......	......	13
14	Land plaster	33.3	30.3	44.3	36.0	3.9	4.9	1.7	3.5	14
	Average of unfertilized plots	24.9	27.0	42.2	31.4	......	......	......	......	

TABLE XX—FERTILIZERS ON CORN IN BUTLER COUNTY.

Yield and increase of STALKS *per acre.*

Plot No.	Fertilizers.	Yield per acre. 1889.	Yield per acre. 1891.	Yield per acre. 1892.	Yield per acre. Average.	Increase per acre. 1889.	Increase per acre. 1891.	Increase per acre. 1892.	Increase per acre. Average.	Plot No.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
1	None	1,320	1,652	2,710	1,894	....	....	....	....	1
2	Superphosphate	2,690	1,952	2,650	2,431	1,193	415	10	540	2
3	Muriate of potash	2,700	1,683	4,210	2,864	1,027	266	1,640	977	3
4	None	1,850	1,300	2,500	1,883					4
5	Nitrate of soda	2,000	1,447	2,800	2,082	....	....	....	....	5
6	Nitrate and superphosphate	2,650	2,020	2,950	2,540	67	—20	383	143	6
7	None	2,100	1,800	2,250	2,050	633	387	617	546	7
8	Superphosphate and potash	3.400	1,761	3,250	2,804	....	....	....	....	8
9	Nitrate and potash	2,550	2,034	3,200	2,595	1,417	—93	950	758	9
10	None	1,750	1,963	2,400	2,038	683	125	850	553	10
11	Superphosphate, potash and nitrate	3,370	2,173	2,990	2,844	....	....	....	....	11
12	Barnyard manure	4,680	2,835	3,980	3,832	1,530	205	557	764	12
13	None	2,020	1,977	2,500	2,166	2,750	863	1,513	1,709	13
14	Land plaster	2,380	1,869	2,700	2,316	....	....	....	....	14
						360	—108	200	150	
	Average of unfertilized plots	1,808	1,738	2,472	1,973	....	....	....	....	

Mr. Brown has succeeded in obtaining a much larger average increase from the use of potash and barnyard manure than has been obtained on the Station farms. The average increase on plots 2 and 3, if it can be maintained, will pay the cost of the superphosphate and potash, used separately, corn being valued at forty cents per bushel ;' but this increase is no greater on plot 8, where the superphosphate and potash are used in combination, than on plot 3, where potash only is used. Nitrate of soda has been used at a loss in the average, but the barnyard manure has certainly yielded a handsome profit.

FARM TEST IN WASHINGTON COUNTY.

Made by Orlando Trotter.

Mr. Orlando Trotter, of Layman, Washington county, has made this test in 1891 and 1892, but on different land each time—a timothy sod in 1891 and a wheat stubble with one year's growth of clover in 1892. The land in both cases has been under cultivation for many years. The results of both experiments are given in table XXI.

TABLE XXI.—FERTILIZERS ON CORN IN WASHINGTON COUNTY.

1 bushel=70 pounds of ears.

Plot number.	Fertilizers.	Yield per acre. Grain, bushels. 1891.	Yield per acre. Grain, bushels. 1892.	Yield per acre. Grain, bushels. Average.	Yield per acre. Stalks, pounds. 1891.	Yield per acre. Stalks, pounds. 1892.	Yield per acre. Stalks, pounds. Average.	Increase or decrease (—) per acre. Grain, bushels. 1891.	Increase or decrease (—) per acre. Grain, bushels. 1892.	Increase or decrease (—) per acre. Grain, bushels. Average.	Increase or decrease (—) per acre. Stalks, pounds. 1891.	Increase or decrease (—) per acre. Stalks, pounds. 1892	Increase or decrease (—) per acre. Stalks, pounds. Average.	Plot number.
1	None	33.9	28.3	31.1	1,731	2,780	2,255	....	....	....	....	....	....	1
2	Superphosphate	50.5	25.7	38.1	1,913	2,520	2,216	15.5	—2.0	6.7	252	—107	42	2
3	Muriate of potash	47.3	22.6	35.0	1,890	2,700	2,295	11.6	—4.6	3.5	300	107	203	3
4	None	37.3	26.6	31.9	1,520	2,500	2,010	....	....	....	....	....	....	4
5	Nitrate of soda	46.1	31.7	38.9	1,905	2,160	2,032	8.6	6.4	7.5	330	—267	31	5
6	Nitrate and superphosphate	51.2	41.4	46.3	1,771	2,860	2,315	13.5	17.5	15.5	141	507	324	6
7	None	37.9	22.6	30.2	1,685	2,280	1,982	....	....	....	....	....	....	7
8	Superphosphate and potash	47.2	21.4	34.3	1,970	2,640	2,305	7.9	—3.0	2.4	222	340	281	8
9	Nitrate and potash	47.8	43.1	45.4	1,850	2,640	2,245	7.1	16.9	12.0	40	320	180	9
10	None	42.1	28.0	35.0	1,873	2,340	2,106	....	....	....	....	....	....	10
11	Superphosphate, potash and nitrate	48.8	60.3	54.5	1,815	3,020	2,417	8.0	31.2	19.6	—11	647	318	11
12	Barnyard manure	48.0	37.1	42.5	1,962	2,680	2,321	8.6	6.8	7.7	184	273	228	12
13	None	38.1	31.4	34.7	1,731	2,440	2,085	....	....	....	....	....	....	13
14	Land plaster	48.9	26.6	37.7	1,892	2,520	....	10.8	—4.8	3.0	161	80	120	14
15	Bowker's superphosphate, 100 pounds	....	26.3	....	....	2,350	....	....	—5.1	....	....	—90	....	15
16	" " 200 "	....	25.0	....	....	2,630	....	....	—6.4	....	....	190	....	16
	Average of unfertilized plots	37.9	27.4	....	1,708	2,468	....	....	....	....	....	....	....	

The results of the two experiments are contradictory, so far as the apparent effect of superphosphate and potash is concerned. In 1891, on sod, every plot upon which these were used showed an increased yield of grain, even in the absence of nitrogen, while in 1892, on stubble, the results are in harmony with the average results at Columbus and in Columbiana county, in showing a loss of grain from the use of superphosphate or potash uncombined with nitrogen. Every plot treated with nitrate of soda, however, shows some increase of grain in both seasons, and this is the rule in all our experiments, although there are some exceptions, but the increase is seldom sufficient to pay the cost of the fertilizer.

CONCLUSIONS.

In almost every instance in all our field experiments on corn, an increase of crop has followed the use of nitrate of soda in combination with muriate of potash or superphosphate, one or the other, and it seems to make very little difference which, but the increase has frequently been reduced when both superphosphate and potash have been added to the nitrate.

In all our work with fertilizers, upon wheat and oats as well as corn, the effect of phosphoric acid seems to be chiefly shown in the stalk and straw. When plants are grown in selected soil in boxes, superphosphate, when used alone, produces a tall, pale, spindling growth of plant, and this may be observed to some extent in the field; but when nitrogen is added the color of the plant is immediately changed to dark green, the leaves appear broader and the entire plant manifests greater vigor.

Apparently, an excess of phosphoric acid stimulates the growth of stalk and straw at the expense of the grain, and thus in wheat the weight of straw may be increased and that of the grain at the same time diminished, while in corn both stalk and grain may be reduced by the less perfect development of leaf. This phenomenon has been manifested so frequently in our experiments that there is no longer room to doubt that *the yield of grain may be actually reduced by the use of fertilizers containing phosphoric acid or potash but no nitrogen.*

But it does not follow that the extensive purchase of nitrogen is necessary. A careful study of these experiments will show that nearly if not quite every case, in which a profitable increase of grain has followed the use of superphosphate without nitrogen, occurred either on sod or on soils which had been cropped in systematic rotation, whereby a good supply of decaying vegetation had been maintained; this decaying vegetation apparently furnishing the nitrogen required to balance the phosphoric acid added in the fertilizers.

It would seem, therefore, that if chemical fertilizers are to be used with any prospect of profit in the production of cereal crops it must be in connection with the culture of some nitrogen-storing crop, such as

clover, grown as frequently as possible in order to secure the greatest possible accumulation of vegetable matter in the soil; for at the present prices of fertilizers and cereal grains respectively it is a hopeless undertaking to attempt to supply, in chemical fertilizers, the quantity of phosphoric acid, potash and nitrogen, all three required to produce a crop or any increase in crop.

A bushel of Ohio grown wheat, with its straw, should contain about three-fourths of a pound of phosphoric acid, a pound of potash and a pound and three quarters of nitrogen. In a bushel of Ohio grown corn, with its stalks and cobs, may be found about three quarters of a pound of phosphoric acid, two-thirds of a pound of potash, and a pound and one-tenth of nitrogen.

At present prices of fertilizing materials in Ohio, the phosphoric acid and potash in a bushel of wheat would cost about 9 cents and the nitrogen about 33 cents, a total of 42 cents. The phosphoric acid and potash in a bushel of corn would cost about 8 cents and the nitrogen about 21 cents, total, 29 cents.

If, now, it were possible to recover in the crop all the fertilizing materials applied to the soil we might raise wheat and corn at a profit on purchased fertility; but this is not possible, for the soil is so constituted that it immediately seizes upon and converts into insoluble combinations a considerable proportion of the phosphoric acid and potash; while of the nitrogen, if applied as nitrate, a larger or smaller proportion, owing to the season, is sure to be washed out of the soil by rains. Thus, in the experiments at Rothamsted, where chemical fertilizers have been used continuously for fifty years, under the most favorable conditions less than half the phosphoric acid, potash or nitrogen applied in the fertilizer has been realized in the increase of crop, and in our experiments the return for the fertilizer is far below that of Rothamsted. The Rothamsted experiments show that a portion, at least. of the unused phosphoric acid and potash may be simply stored in the soil to be given up to future crops; but they also show that it will require many years of cropping, to get back all that has been given to the soil.

SUMMARY.

The experiments of this Station with fertilizers now include four years' continuous culture of wheat on the same land, with and without fertilizers, on the farm hitherto occupied by the Station in Columbus and belonging to the State University; three years' similar culture of wheat in Columbiana county; four years' continuous culture of oats on the Columbus farm; five years' continuous culture of corn on the Columbus farm and in Columbiana county, and fourteen co-operative experiments, made in 1889, 1890, 1891 and 1892 by farmers in Ashtabula, Holmes, Miami, Huron, Licking, Butler and Washington counties, besides several

years' study of crops grown in rotation and of plants grown in boxes.

These experiments must be continued farther before positive conclusions can be drawn, but at the present date the following tentative conclusions seem to be justified:

(1.) The use of superphosphate and potash, separately or in combination, but without nitrogen, has frequently caused a loss of grain in crops of corn and wheat on soils deficient in vegetable matter.

(2.) The yield of straw or stalks has almost invariably been increased by the use of superphosphate.

(3.) The use of superphosphate has frequently, and that of potash has occasionally been followed by a considerable increase of crop, both of grain and straw or stalks, on sod ground or land containing an abundance of decomposing vegetable matter.

(4.) An increase of grain in the crop has generally followed the use of nitrate of soda, and this has happened in almost every case when the nitrate has been used in combination with superphosphate or potash.

(5.) When a complete fertilizer has been used, containing both phosphoric acid and potash, in combination with nitrogen, the phosphoric acid being carried in less active forms than bone-black superphosphate, an increase of crop has resulted in practically every case; but at present prices of fertilizers and grain respectively, this increase has invariably cost more than its value in the market.

(6.) While, therefore, these experiments demonstrate the possibility of producing a regular and certain increase in the yield of cereal crops by the use of a complete chemical fertilizer, yet they show that if such fertilizers are to be used with any prospect of profit in Ohio in the production of cereal crops and as a part of a regular system of agriculture, that system must provide for the accumulation in the soil of the largest possible quantity of organic nitrogen, through the culture, in short rotations, of plants which have the power of obtaining nitrogen from sources inaccessible to the cereals.

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EXPERIMENTS IN FEEDING FOR MILK.

BY CHAS E. THORNE, J. FREMONT HICKMAN AND F. J. FALKENBACH.

I.—CORN SILAGE VS. FIELD BEETS AS FOOD FOR MILK PRODUCTION.

In the Bulletin of this Station for June, 1889, is reported an experiment in the comparative feeding of corn silage and field beets to dairy cows, twelve cows being used in the experiment, which continued eight weeks. In this experiment there was apparently a greater production of milk while the cows fed on beets, but a greater increase of live weight while they fed on silage.

The experiment was repeated the following winter, twelve cows again being put under test over a period of ten weeks. The results of this test were given in the Bulletin for June, 1890. Briefly stated, the cows not only gave more milk on the average, but also showed a greater average increase in live weight while feeding on beets than on silage.

During each of the next two winters the experiment was repeated, with sixteen cows under test in each case. Following is a detailed report of these tests:

EXPERIMENTS OF 1891 AND 1892.

Sixteen cows were selected for each of these tests from the herd of thirty or more belonging to the Station, eight of which were registered Jerseys and eight were grades, chiefly high-grade Short-horns. These cows were divided as before into four lots, a, b, c and d, each lot containing two grades and two Jerseys. Further data respecting the cows are given in Tables I and II

TABLE I.—DATA CONCERNING COWS UNDER TEST IN 1891.

Lot.	Cow.	Age–Yrs.	Breed.	Date of last calving.
A	No. 1	7	Short-horn grade	June 3, 1890.
	No. 9	9	Short-horn grade	October 16, 1890.
	Myrtle Bacon, 46,669	6	Jersey	October 31, 1890.
	Lady Lyle, 9,498	13	Jersey	September 16, 1890.
B	No. 20	7	Short-horn grade	December 7, 1890.
	No. 14	9	Short-horn Jersey	October 8, 1890.
	Cedrica Bacon, 49,407	5	Jersey	May 30, 1890.
	Madge Page, 47,395	5	Jersey	October 2, 1890.
C	No. 5	7	Short-horn grade	October 1, 1890.
	No. 24	5	Devon-Jersey	December 10, 1889.
	Lyline, 47,398	4	Jersey	December 3, 1890.
	Regia Bacon, 47,399	4	Jersey	September 28, 1890.
D	No. 21	9	Short-horn grade	October 27, 1890.
	No. 8	6	Short-horn grade	July 17, 1890.
	Deletta, 46,764	4	Jersey	November 29, 1890.
	Misty May, 46,765	4	Jersey	September 10, 1890.

TABLE II.—DATA CONCERNING COWS UNDER TEST IN 1892.

Lot.	Cow.	Age–Yrs.	Breed.	Date of last calving.
A	No. 25	7	Short-horn grade	October 1, 1891.
	No. 9	10	Short-horn grade	October 27, 1891.
	Myrtle Bacon, 46,669	7	Jersey	November 26, 1891.
	Regia Bacon, 47,399	5	Jersey	July 12, 1891.
B	No. 20	8	Short-horn grade	December 2, 1891.
	No. 26	6	Short-horn grade	October 1, 1891.
	Cedrica Bacon, 49,407	6	Jersey	August 26, 1891.
	Madge Page, 47,395	6	Jersey	August 28, 1891.
C	No. 13	9	Short-horn grade	May 1, 1891.
	No. 24	6	Devon-Jersey	October 27, 1891.
	Lyline, 47,398	5	Jersey	December 20, 1891.
	Etta's Pride, 47,400	5	Jersey	March 17, 1891.
D	No. 21	10	Short-horn grade	October 12, 1891.
	No. 8	7	Short-horn grade	September 10, 1891.
	*Deletta, 46,764	5	Jersey	October 13, 1891.
	Bacon Maid, 47,397	5	Jersey	June 1, 1891.

*Deletta became sick during the test and was withdrawn near its close, hence the calculations of food and product for lot D in 1892 are based upon the records of the other three cows only.

In each experiment, lots A and B were alternated with lots C and D, lots A and B receiving beets as part of their ration for a period of three weeks, while lots C and D had silage, and *vice versa*. The treatment of lots A and B and of C and D differed only in the kind of meal fed, lots A and C receiving daily six pounds of corn meal, while lots B and D received instead a mixture of three pounds each of wheat bran and old process linseed oil meal, these meal rations being continuous throughout the experiment.

In 1891 the actual test began February 10th and ended April 13th, extending over three periods of three weeks each; but this was preceded by a period of three weeks in which the cows were gradually accustomed to the feeding stuffs to be used in the experiment. The supply of beets was exhausted at the end of the first week of the third period, and for the remaining two weeks silage was substituted, so that we have in the case of lots A and B only one period of full feeding on beets to compare with one on silage, while lots C and D had one period of beet feeding between two periods of silage feeding.

In 1892 the preliminary feeding began January 9th and the actual test ten days later, but owing to a misunderstanding on the part of the feeders full records were not kept for the 19th, 20th and 21st, hence the first period contains only 18 days, the remaining periods extending over three full weeks each.

The cows were milked twice each day by the same men and in the same order. The hay and meal were fed morning and evening only, but the silage and beets were given in three feeds, morning, noon and night. At about ten o'clock each morning the cows were weighed, then allowed to drink from a tub of water standing on scales, by which means the amount drank was determined, then on fair days they were turned out of doors until one o'clock P. M.

Following is the percentage of total dry matter* in the various feeding stuffs used, being in most cases the average of several determinations:

TABLE III.—TOTAL DRY MATTER IN FEEDING STUFFS.

1891.	Per cent.	1892.	Per cent.
Clover hay	93.05	Blue grass hay	94.03
Corn silage	24.75	Corn silage	27.92
Mang ls	11.80	Mangels	9.60
Corn meal	84.60	Corn meal	84.60
Bran	90.35	Bran	90.35
Linseed oil meal	92.54	Linseed oil meal	92.54

*By "dry matter" is meant the absolutely dry product obtained by drying the material for several hours at a temperature of 212° Fah.

Separate determinations were not made of the bran and meals for the two experiments, but as uniform lots were used throughout each experiment and the rations were identical in both tests, the comparison is not affected.

Had the cows consumed the same quantity of hay while feeding on beets as on silage they would have received a little more dry matter in the silage than in the beet ration; but they ate a decidedly larger quantity of hay while eating beets, and this has been our uniform experience in feeding beets. They increase the appetite for other foods.

THE SILAGE.

The silage was made from Indian corn, so grown as to produce considerable grain, and preserved in good condition. That used in 1891 was made from corn planted June 7th and harvested September 23d to October 4th, when most of the fodder was quite dry and the corn was ripe enough to shock without danger of spoiling. The per cent. of corn on the cob found in this silage averaged 17½, equivalent to about 14 per cent. actual grain.

The corn used in the experiment of 1892 was planted May 30th and harvested September 26th to October 3rd, and was put into the silo in riper condition than in any previous season. An average of 16 per cent. of ear corn was found in the silage, equivalent to about 13 per cent. actual grain.

The silage was fed at the rate of 30 pounds per cow per day, in three equal feeds, morning, noon and night. In 1891 it was eaten clean by half the cows, and the quantity refused by others was comparatively small; but in 1892 no cow ate her silage clean throughout both periods of the test.

Determinations of dry matter in the silage indicated an average of 24.75 per cent. in 1891 and 27.92 per cent. in 1892. The cows ate an average of 28.71 pounds per cow per day in 1891 and 24.82 pounds per day in 1892. The actual dry matter consumed in silage was 7.11 pounds per cow per day in 1891 and 6.94 pounds per day in 1892, a daily difference of 0.17, or one-sixth of a pound.

In the last experiment five or six determinations of the percentage of grain in the silage were made during each period, and these show the following averages: Period I, 13½; period II, 16; period III, 18; period IV, 17½. Lots A and B received silage during periods I and III, and ate an average of 25.24 and 21.25 pounds per cow per day. Lots C and D received silage during periods II and IV, and ate an average of 27.65 and 25.15 pounds per cow per day. In both cases, therefore, the quantity eaten was in inverse ratio to the amount of grain in the silage. The

larger quantity of grain in the silage indicates a closer approach to the conditions of ordinary field culture of corn, other things being equal, conditions which produce a comparatively large proportion of coarse stalks, and it was these stalks which the cows rejected. Theoretically, this waste would be expected to be partly offset by the superior quality of the silage containing the most grain, and previous experiments indicate that silage containing a low percentage of grain has a relatively low feeding value, but there would seem to be a middle ground worth striving for.

It is not forgotten that the smaller consumption of silage occurred later in the season, when other factors, such as increased temperature of the air and increased age of the silage may have operated to check the cows' appetite for it; but in the experiment of 1891, which ended on practically the same date as that of 1892, nearly all the silage was eaten, and in that of 1890, ending two weeks later, all the silage was eaten throughout the test. The experiment of 1889 began March 1st and ended April 27th; the cows received 40 pounds of silage per head per day, and ate the quantities indicated below:

TABLE IV.—POUNDS OF SILAGE CONSUMED PER COW PER DAY IN 1889.

Lot.	Period I. March 1–14.	Period II. March 15–28.	Period III. March 29–April 13.	Period IV. April 14–27.
A....	35.6	36.5	36.2	33.7
C...	38.3	....	37.3	....
D...	....	35.0	....	35.2

In this experiment lot A was fed on silage and lot B on beets throughout the test, lots C and D being fed in alternating periods. No estimate was made of the percentage of grain in the silage, but the corn was more mature when put into the silo than in 1890. That used in 1890 was not planted until June 19th and 20th. In this experiment the lot continuously fed on silage consumed a smaller quantity during the latest period of the test, but in the case of the alternating lots the difference is not sufficient to justify the assumption that the silage was less palatable then than earlier.

As the matter stands, the question of the state of maturity in which silage corn should be harvested seems worthy of further investigation.

THE BEETS.

In the experiment of 1889 the cows rejected on the average ten per cent. and in that of 1892 six per cent of the total silage fed; but in both tests there were individual cows which refused a much larger proportion, whereas beets have been eaten by so nearly every cow to which we have ever fed them that the exceptions amount to nothing. In the two experiments now under consideration, less than one bushel of beets was refused out of more than a thousand fed, and this was all refused by one cow in 1891.

The beets were of the "long red" variety of mangels. Those grown for the test of 1891 were planted May 5th on timothy sod and harvested October 24th to 26th inclusive; and those grown for the test of 1892 were planted May 3d, on land dressed with barnyard manure at the rate of sixteen tons per acre before plowing, and were harvested October 25th to 30th. Those grown in 1890 showed an average of 11.8 per cent. of dry matter, and in 1891, 9.6 per cent.

THE HAY.

Clover hay was fed in the experiment of 1891, and hay made from Kentucky blue grass, cut from the College lawn early in June, in 1892. The clover hay showed 93.05 per cent. dry matter and 12.25 per cent. protein, the blue grass hay 94.03 per cent. dry matter and 8.01 per cent. protein. In 1891 the cows ate an average of 17.00 pounds hay per cow per day while on beets and 12.54 pounds while on silage, and in 1892 they ate 17.50 pounds per day while on beets and 11.52 pounds while on silage.

It was part of the plan of the experiment that all the cows should receive more hay than they could eat, and that the uneaten residuum should be weighed back and thrown away or fed to other stock. This plan was fairly executed in 1891, but in 1892 several of the cows in lots A and B manifested a dislike for the silage, and in order to induce them to eat more of it their hay ration was restricted while on silage. They were so fed, however, that there was always a considerable uneaten residuum of either hay or silage. Lots C and D ate the silage fairly well, and always left some hay in their mangers, and all the cows were so fed that there was hay left while on the beet rations; but to accomplish this it was necessary to feed a much larger quantity of hay while on beets than on silage.

FOOD CONSUMED.

The following table shows the average amount of food consumed per cow per day by the alternating lots:

TABLE V—POUNDS OF FOOD CONSUMED.

Lots.	Food.	1891. Period. 0	1891. Period. I	1891. Period. II	1891. Period. III	1892. Period. I	1892. Period. II	1892. Period. III	1892. Period. IV
A & B	Hay	12.72	17.80	16.23	14.31	11.40	17.82	12.34	16.75
	Silage	....	....	28.42	....	25.24	....	21.25	....
	Beets	....	50.00	....	....	....	50.00	....	50.00
	*Meals	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Total dry matter	....	27.74	27.41	....	23.05	26.83	22.82	25.83
C & D	Hay	9.68	11.47	16.21	9.92	18.01	11.41	17.43	10.93
	Silage	....	28.57	....	29.14	....	27.65	....	25.15
	Beets	....	....	49.50	....	50.00	....	50.00	....
	*Meals	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Total dry matter	....	23.02	26.23	21.72	26.84	23.70	26.44	22.55

* Corn meal, or bran and oil meal. See *ante*.

It will be observed that in every case the average consumption of hay and of total dry matter has been greater when beets were being fed than during the periods of silage feeding. The only case in which the difference was not very decided was in period II of 1891, when the margin was small, and when several cows reversed the rule which has at other times prevailed almost without exception. The only explanation we can offer for this exception is that during this period all the cows manifested an increased appetite, gave a larger flow of milk and gained in live weight. Reference to the charts which follow will show that this was a period of rising temperature and moderate fluctuations of the barometer. The records of the Station's Meteorologist for that period (March 3–23) show that rain fell on twelve of the twenty-one days.*

In the general average the cows consumed in 1891, 26.98 pounds of dry matter per cow per day while on beets and 24.89 pounds while on silage, and in 1892, 26.48 pounds while on beets and 23.03 pounds while on silage.

YIELD OF MILK AND BUTTER FAT.

In the following table is given the average yield in pounds of milk and butter fat for the alternating lots:

* In the annual report of the Wisconsin Agricultural Experiment Station for 1892, page 67, is reported a similar increase in flow of milk under similar conditions of weather.

TABLE VI—YIELD OF MILK AND BUTTER FAT PER COW PER DAY.

Lots.	Product.	1891.				1892.			
		Period and food.				Period and food.			
		0	I. Beets.	II. Silage	III.	I. Silage	II. Beets.	III. Silage	IV. Beets.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
A & B	Milk	17.56	17.50	18.07	17.66	17.90	18.02	17.57	18.04
	Butter fat	.644	.616	.571	.594	.797	.780	.761	.771
			Silage	Beets.	Silage	Beets.	Silage	Beets.	Silage
C & D	Milk	14.92	14.70	15.76	15.07	19.38	17.30	18.01	17.07
	Butter fat	.589	.580	.598	.610	.883	.800	.839	.716

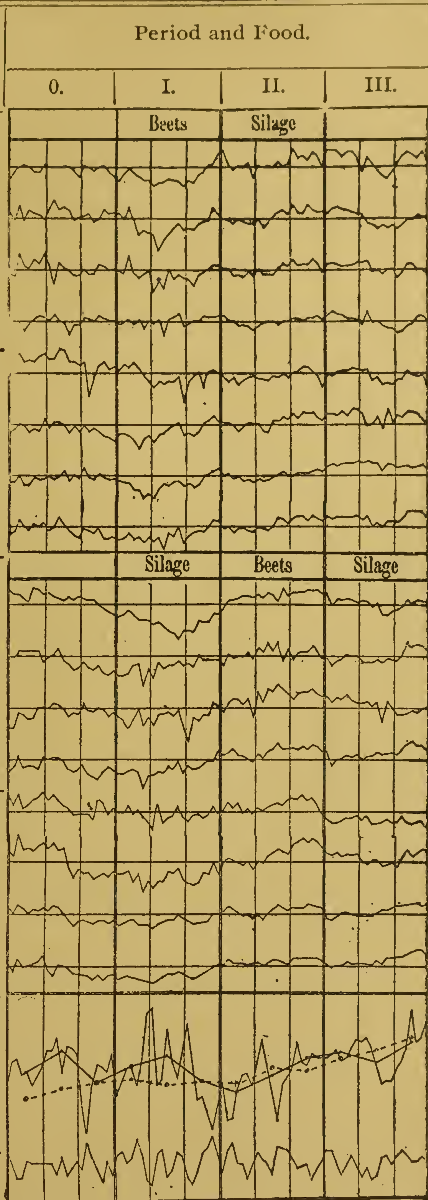
In 1891 the average yield of milk from 16 cows was 16.63 pounds, per cow per day while feeding on beets and 16.48 pounds while on silage, and in 1892 it was 18.36 pounds while on beets and 17.46 pounds while on silage, a gain of 0.15 pound of milk per cow per day for the beet ration in 1891 and 0.90 pound per day in 1892. In 1890 the increased flow of milk on the beet ration was found to average 1.34 pound per cow per day and in 1889 0.24 pound. The average yield and daily variations in flow of milk are graphically shown in diagrams I and II.

The percentage of butter fat was determined once each week by Babcock's test. In the average milk from all the cows 3.656 per cent. of fat was found in 1891 while the cows were feeding on beets and 3.5[illegible]2 per cent. while on silage, and in 1892, 4 455 per cent. on beets and 4.404 per cent. on silage.* The average total butter fat found in the milk per cow per day in 1891 was .607 pounds while the cows fed on beets and .587 pounds on silage, and in 1892 it was .818 pounds on beets and .769 on silage. The test would have been more satisfactory had the fat determinations been made daily; but they indicate that the percentage of fat in the milk was not materially affected by the feed, but that the total quantity of fat varied approximately with the flow of milk, and this was undoubtedly increased by the beets.

*In our first experience with the Babcock test our readings were too low, owing to an error in manipulation. This error, however, does not affect the comparison here made, since it runs uniformly throughout the experiment of 1891. The readings of 1892 are believed to be correct.

DIAGRAM I—AVERAGE YIELD AND DAILY VARIATIONS IN MILK FLOW IN EXPERIMENT OF 1891.

Lot.	Cow.	Average daily yield.
		Pounds.
A	No. 1.........	24.45
	No. 9.........	22.49
	Myrtle.......	18.43
	Lady.........	9.30
B	No. 20........	24.82
	No. 14........	18.39
	Cedrica	13.84
	Madge.......	9.88
C	No. 5.........	20.74
	No. 24........	15.97
	Lyline........	14.74
	Regia.........	8.34
D	No. 21........	21.02
	No. 8	19.86
	Deletta......	10.06
	Misty.........	10.60
Temperature*...................		60° 50° 40° 30° 20° 10°
Barometer............................		



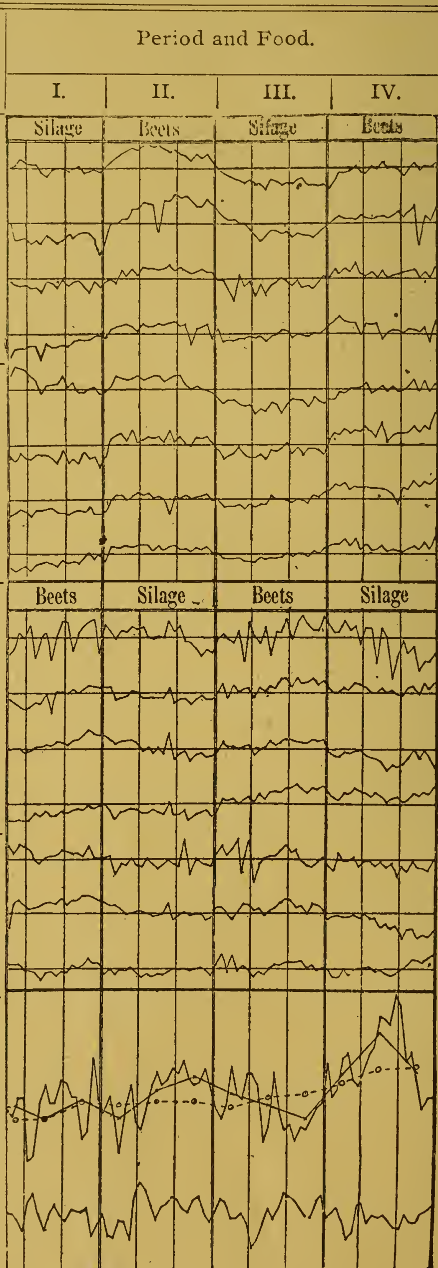
*The continuous lines indicate the daily variations and weekly means in temperature; the dotted lines the ten years' average.

DIAGRAM II—AVERAGE YIELD AND DAILY VARIATIONS IN MILK FLOW IN EXPERIMENT OF 1892.

Lot.	Cow.	Average daily yield.
		Pounds.
A	No. 25.......	23.72
	No. 9.........	21.35
	Myrtle.......	19.41
	Regia	10.47
B	No. 20........	25.65
	No. 26........	19.01
	Cedrica	11.68
	Madge.......	11.80
C	No. 13........	18.23
	No. 24........	16.05
	Lyline.	22.41
	Etta..........	18.17
D	No. 21........	19.75
	No. 8.........	18.52
	Maid.........	13.23

Temperature....................70° 60° 50° 40° 30° 20° 10°

Barometer...............................



RATIO OF DRY MATTER IN FOOD TO YIELD OF MILK.

It is evident that the feeding of beets uniformly tends to increase the flow of milk; but it has also been shown that beets increase the consumption of other foods, and this raises the question whether the beets increase or diminish the actual effectiveness of the food. This question can only be answered by reducing all the foods to the basis of dry matter and then comparing the results. On this basis we find that in 1891 the sixteen cows produced 62 pounds of milk for each hundred pounds of dry matter consumed in the beet ration, against 66 pounds of milk per hundred of dry matter in the silage ration, and in 1892 they produced 69 pounds and 76 pounds of milk, respectively, per hundred of dry matter in the two rations. In the experiment of 1890, which showed the largest increase in milk on the beet ration, the milk production for one hundred pounds of dry matter was 59 pounds on beets and 60 pounds on silage. In the experiment of 1889 the first period of beet feeding should be excluded, as the progress of the experiment showed that the cows did not have all the hay they would have eaten during this period. Excluding it, the production of milk for the two alternating lots averaged 59 pounds on beets and 62 pounds on silage. Thus it appears that in the general average of all these experiments a hundred pounds of dry matter has produced about four pounds, or approximately six per cent. more milk when the cows were feeding on silage than on beets.

EFFECT UPON LIVE WEIGHT.

In the experiment of 1891 the daily weight of the sixteen cows averaged 852 pounds while feeding on beets and 849 pounds while feeding on silage. In 1892 these weights were 974 and 960 pounds respectively. In 1890 the average daily weight of the six cows fed in alternating lots was 996 pounds while on beets and 978 pounds while on silage, and in 1889 the corresponding weights were 1,104 pounds and 1,100 pounds. In the average of the four tests the live weight was 950 pounds while on beets and 941 pounds while on silage. In every test there was a marked increase in weight when the cows were changed from silage to beets, and a marked decrease when the opposite change was made. An examination of diagrams III and IV, and of the similar diagrams published in the report of the experiment of 1890, will show that in most cases these fluctuations in live weight began immediately upon the change of feed, thus indicating that they may have been due, in part at least, to the increased weight of the food and water taken with the beets, which will be referred to further on. It will be observed, however, that in the majority of cases the cows continued to increase in weight while feeding on beets, and were heavier during the last week of the period than during the first; this happened in 32 out of the 48 individual cases, whereas in the 56 individual cases of silage feeding the cows showed a gain in but 24 cases. There were four cases of slight loss in weight while feeding on beets and

sixteen similar cases while on silage. If, however, we exclude the first week of each silage-feeding period to allow the contents of the digestive tract to resume their normal weight, we find that in 33 cases the average live weight was greater during the third week than during the second, and in 12 cases it was less.

DIAGRAM III.—AVERAGE LIVE-WEIGHT AND DAILY FLUCTUATIONS IN EXPERIMENT OF 1891.

Lot.	Cow.	Average weight.
		Pounds.
A	No. 1.........	1,040
	No. 9.........	914
	Myrtle.......	808
	Lady..........	709
B	No. 20........	1,025
	No. 14........	887
	Cedrica......	737
	Madge........	772
C	No. 5.........	839
	No. 24........	881
	Lyline........	688
	Regia	970
D	No. 21........	987
	No. 8.........	974
	Deletta	713
	Misty.........	717

Temperature .... 60° 50° 40° 30° 10°

Barometer.......................................

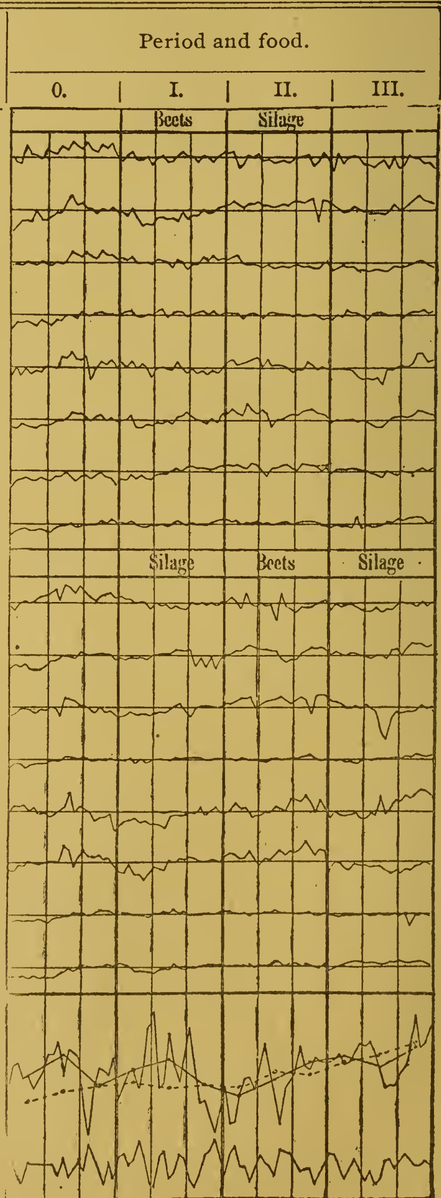
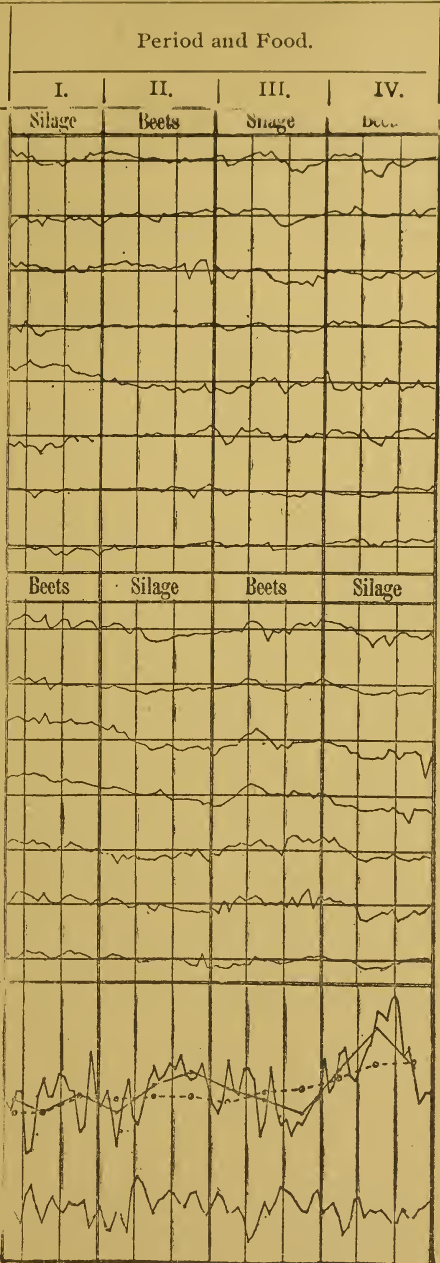


DIAGRAM IV.—AVERAGE LIVE-WEIGHT AND DAILY FLUCTUATIONS IN EXPERIMENT OF 1892.

Lot.	Cow.	Average weight.
		Pounds.
A	No. 25........	1,020
	No. 9.........	999
	Myrtle.......	861
	Regia	996
B	No. 20........	1,103
	No. 26........	1,085
	Cedrica.......	828
	Madge	875
C	No. 13........	1,002
	No. 24..	1,028
	Lyline	797
	Etta..........	972
D	No. 21........	1,047
	No. 8.........	1,101
	Maid.........	785
Temperature		70° 60° 50° 40° 30° 20° 10°
Barometer..................................		



In 1889 the lot continuously fed on silage made a regular gain, averaging about five pounds per cow per week throughout the eight weeks of the test, and gave at the same time an average of 12.6 pounds of milk per day per cow. In 1890 the lot similarly treated, but fed on less mature silage, lost in weight at the rate of about three pounds per cow per week. In the same tests the lots continuously fed on beets showed an average gain in weight of about two pounds per cow per week in 1889 and four pounds in 1890, although two cows lost weight in 1889 and one remained stationary in 1890.

Considering all the tests we must conclude that a part of the increased live weight shown while feeding on beets was actual gain, but the data are not sufficient to justify an estimate of the average amount of gain. The gains in live weight have been more uniform while feeding on beets, as would be expected from the greater regularity with which the beets were eaten.

WATER DRANK.

Table VII shows the average number of pounds of water drank per cow per day in each lot of cows throughout the two experiments, beginning with February 15, 1891:

TABLE VII.—POUNDS OF WATER DRANK.

Lot.	1891.			1892.			
	Period and food.			Period and food.			
	I.* Beets.	II. Silage.	III.	I. Silage.	II. Beets.	III. Silage.	IV. Beets.
A	45.2	59.4	56.9	58.2	65.8	55.0	57.0
B....................	52.7	65.7	61.2	63.2	67.2	59.1	66.8
A and B.........	48.9	62.5	59.0	60.7	66.5	57.0	61.9
	Silage.	Beets.	Silage.	Beets.	Silage.	Beets.	Silage.
C.......	45.9	48.9	52.4	56.2	53.8	60.8	59.5
D..........	45.4	47.9	47.6	52.0	46.5	56.3	57.9
C and D.........	45.6	48.4	49.5	54.1	50.1	58.7	58.7

* Sixteen days.

In 1891 the average amount of water drank was larger while the cows were eating silage, and in 1892 it was larger while they were eating beets. In 1891 there was a general increase in the amount of water drank during the second period, accompanying the generally increased

consumption of food, flow of milk and gain in live weight previously referred to. In 1892 the amount of water drank varies in general harmony with the amount of dry matter consumed in the food. Apparently, the 80 pounds of water found in the daily beet ration in excess of that found in the silage ration has had no proportionate effect in satisfying the desire of the cows for water. In the general average of the two experiments, the cows consumed 127 pounds of food and drink per head per day while on beets and 101 pounds while on silage, a difference of 26 pounds per day. One pound of this may be accounted for in the increased flow of milk and possible gain in live weight while on beets, leaving 25 pounds to be found in the excretions.

RELATIVE DIGESTIBILITY OF THE DRY MATTER OF BEETS AND SILAGE.

As the result of digestion experiments it has been assumed that the dry matter of roots is almost wholly digestible, while from one-fourth to one-third or more of the dry matter of hay, silage and other coarse fodders is found to be indigestible. It is also claimed that roots diminish the digestibility of coarse fodders fed in connection with them. In these experiments no attempt has been made to determine the relative digestibility of the two feeding stuffs under comparison, their relative effectiveness as milk producers being the only point aimed at, and it would seem that a greater relative increase of live weight due to the beets than the experiments seem to indicate must be found before we can safely assume a greater effectiveness for a pound of dry matter in beets than in silage. If the assumption that beets decrease the digestibility of hay, etc., is correct, it amounts to the same thing in practice as though their own dry matter were no more digestible than that of other foods.

THE RELATIVE COST OF BEETS AND CORN SILAGE.

The farm upon which the experiments herein described were made is well adapted to the production of corn, its average yield for the twelve years ending with 1890 being about 57 bushels of shelled corn per acre. Such a crop of grain, with the stalks and leaves carrying it, would contain about 6,000 pounds of dry matter.

On the same land and during the same period the average crops of field beets have amounted to 15¾ tons per acre, equivalent to a little more than 3,000 pounds of dry matter per acre. The cost per acre of raising and harvesting the beets has been greater than that of raising and harvesting the corn, so that the dry matter of the beets has cost more than double that of the corn.

At this difference of cost our experiments plainly show that beets cannot be used with economy as a considerable part of a feeding ration.

If they are to be used with profit it must be in small quantity and for the purpose of securing their effect as appetizers.

It must be remembered, however, that these experiments have been made in a region where corn is at its best, but which is considerably south of the latitude best adapted to beets. It is quite probable, therefore, that in more northerly regions the use of beets as compared with silage will be found relatively more profitable than is shown in these tests.

RATIO OF NITROGEN TO CARBON IN FOOD.

In planning this experiment the rations were so arranged as to give a wider ratio between the nitrogenous and carbonaceous constituents in the food of lots A and C than in that of lots B and D, but no attempt was made to make a conclusive study of this point, as this would have involved the alternate feeding of these lots and would thus have interfered with the main object of the experiment. The results reached, therefore, must be regarded as of value only when compared with other experiments, planned to illustrate this point chiefly.

In the following table are given the pounds of milk and butter-fat produced by each hundred pounds of dry matter in the food, according as the meal ration was corn meal or the mixture of bran and linseed oil meal, together with the percentage of fat in the milk:

TABLE VIII.—POUNDS OF MILK AND BUTTER FAT AND PERCENTAGE OF BUTTER FAT PRODUCED PER 100 POUNDS OF DRY MATTER IN FOOD.

Lots.	Meal ration.	Milk.		Butter-fat.		Percentage of fat.	
		1891.	1892.	1891.	1892.	1891.	1892.
A and C......	Corn meal..............................	69	75	2.44	3.24	3.51	4.29
B and D......	Bran and oil-meal..................	62	69	2.49	3.18	3.94	4.58

It will be seen that the food having the wider ratio has produced the larger proportionate quantity of milk, in both tests, and that when the ratio was still further increased by the substitution of blue grass hay containing but 8 per cent. protein for clover hay containing 12 per cent. protein, as shown by our analyses, a still larger yield of milk was secured; but it will be observed that although the total quantity of milk has been greater in the case of the cows fed on corn meal, yet the increase of fat has not kept pace with that of milk, the average percentage of fat in the milk in both experiments, and the total quantity of fat in 1891, being relatively smaller in the case of the corn meal fed cows than in that of those fed on bran and oil meal.

It is possible that all the difference here shown may be due to differences in productive power of the different cows. One possible cause of such difference at once suggests itself, namely: the length of time since calving. On this point we find that the average time to the middle of the experiment in 1891 was 197 days for lots A and C, and 165 days for lots B and D; and in 1892 it was 182 days for lots A and C, and 150 days for lots B and D. In the average of the two experiments it was 189 days for lots A and C and 157 days for lots B and D, a difference which should have had an effect just contrary to that observed.

Neither can this factor account for the superior productiveness of the cows in 1892, for if we exclude cow No. 24, which was farrow in 1891 and yet showed a slightly greater productiveness in relation to food consumed than in 1892, we find that the average time since calving was 158 days in 1891 against 169 days in 1892, a difference again contrary to the effect observed. We must therefore conclude either that the blue grass hay, with its smaller proportion of protein, gave a better return than the clover hay, or else that the cows were in better condition for milk production in 1892 than in 1891.

The substitution in 1892 of Etta's Pride and Bacon Maid for Lady Lyle and Misty May was in favor of the later test; but in cases of the grades substituted the average results were in favor of the earlier test.

The average live weights of the ten cows which were used in both tests was greater at the beginning of the test of 1892 than at that of 1891; this was probably the principal cause of the superior productiveness of the food in the latter season.

EFFECT OF WIDE AND NARROW RATIO UPON LIVE WEIGHT.

The alternating periods in these experiments have been found too short to give a trustworthy index to the relative effect of the beets and silage upon the live weight of the cows, but it would seem safe to draw conclusions from periods of twelve weeks continuous feeding, such as we have in the comparison of the corn meal with the bran and oil meal. The results bearing on this point are given below, in a table comparing the average live weight of each lot of cows during the first and last weeks of each experiment:

TABLE IX.—EFFECT OF DIFFERENT MEAL RATIONS ON LIVE WEIGHT, AVERAGE WEIGHT OF COWS AND INCREASE OR DECREASE IN POUNDS.

Lots.	1891.			1892.			Av., 1891 and 1892.		
	First week.	Last week.	Increase or decrease	First week.	Last week.	Increase or decrease	First week.	Last week.	Increase or decrease
A	870	870	0	956	976	20	913	923	10
C	837	845	8	933	950	17	885	897	12
A and C	853	857	4	944	963	19	899	910	11
B	854	869	15	963	988	25	908	928	20
D	864	857	—7*	987	969	—18*	925	913	—12*
B and D	859	863	4	975	979	4	917	920	4

* Decrease.

In the average, the cows receiving the corn meal have made the larger gain in live weight, but the difference is too small and too irregular to justify overlooking the factor of individuality, or natural productive capacity, which we will now consider.

II.—THE PRODUCTIVE CAPACITY OF DIFFERENT COWS.

In Table X is given the age of each cow at the time of each experiment, the number of days between last calving and the middle of the experiment, the average live weight during each experiment and the daily gain or loss in live weight, the daily consumption of dry matter, and the pounds of milk and milk fat produced per day and per 100 pounds of dry matter in the food for each test. In estimating the milk fat for 1891 we have used the percentages given by a gravimetric analysis, made April 4th, instead of those given by the Babcock test, for the reason given on page 58. While the insufficiency of a single analysis is fully recognized, it is believed that the error in this case is smaller than that which would follow the using of the other set of co-efficients.

TABLE X.—PRODUCTIVE CAPACITY OF DIFFERENT COWS.

Breed.	Year.	Cow.	Age.	Days since calving.	Produced by 100 pounds dry matter in food.		Daily gain or loss in live weight.	
					Milk.	Butter fat.	Gain.	Loss.
			Yrs.		Lbs.	Lbs.	Lbs.	Lbs.
Grades	1891	No. 1	7	277	92	3.52	0.300	....
		" 9	9	142	87	3.19	....	0.150
		" 20	7	90	83	3.77	....	0.450
		" 14	9	150	64	3.17	0.300	....
		" 5	7	157	96	3.80	....	0.212
		" 24	5	452	69	3.08	0.125	....
		" 21	9	137	80	3.26	....	0.675
		" 8	6	233	75	3.12	....	0.175
		Average	7.4	205	81	3.36	....	0.117
	1892	No. 25	7	152	95	3.31	....	0.100
		" 9	10	126	87	3.12	0.500	....
		" 20	8	90	93	3.23	....	0.350
		" 26	6	152	76	3.17	0.662	....
		" 13	9	305	74	3.25	....	0.250
		" 24	6	126	64	2.82	0.450	....
		" 21	10	141	77	3.57	....	0.425
		" 8	7	173	73	3.28	....	0.475
		Average	7.9	158	80	3.22	0	0
Jerseys	1891	Myrtle	6	127	68	3.76	....	0.137
		Lady	13	172	40	2.46	0	0
		Cedrica	5	281	54	2.74	0.325	....
		Madge	5	156	39	2.52	0.225	....
		Lyline	4	94	65	4.40	0.087	....
		Regia	4	160	37	2.04	0.412	....
		Deletta	4	98	52	3.29	0.125	....
		Misty	4	178	50	3.00	0.262	....
		Average	5.6	158	51	3.03	0.162	....
	1892	Myrtle	7	96	78	4.05	0.275	....
		Regia	5	233	49	2.72	0.462	....
		Cedrica	6	188	48	2.46	0.625	....
		Madge	6	186	49	3.18	0.525	....
		Lyline	5	72	87	4.08	....	0.187
		Etta	5	349	67	2.61	0.587	....
		Maid	5	274	63	3.17	0.125	....
		Average	5.6	200	63	3.19	0.345	....
		General average	6.6	180	69	3.20	0.090	....

TABLE X—Concluded.

Breed.	Year.	Cow.	Dry matter consumed. Per day.	Dry matter consumed. Per 1,000 lbs. live weight.	Milk produced per day.	Per cent. of fat in milk.	Milk-fat produced per day.
			Lbs.	*Lbs.*	*Lbs.*	*Per cent.*	*Lbs.*
	1891.	No. 1	26.60	25.58	24.45	3.83	0.936
		" 9	25.80	28.23	22.49	3.66	0.823
		" 20	29.89	29.16	24.82	4.54	1.126
		" 14	28.82	32.15	18.39	4.92	0.904
		" 5	21.55	25.68	20.74	3.95	0.819
		" 24	23.12	26.24	15.97	4.49	0.713
		" 21	26.34	26.68	21.02	4.09	0.860
		" 8	26.45	27.16	19.86	4.16	0.826
Grades		Average	26.03	27.61	20.97	4.18	0.876
	1892.	No. 25	25.06	24.57	23.72	3.51	0.833
		" 9	24.61	24.63	21.35	3.57	0.762
		" 20	27.60	25.02	25.65	3.48	0.893
		" 26	25.02	23.06	19.01	4.18	0.795
		" 13	24.69	24.64	18.23	4.40	0.802
		" 24	24.98	24.30	16.05	4.38	0.703
		" 21	25.68	24.52	19.75	4.63	0.914
		" 8	25.34	23.01	18.52	4.51	0.835
		Average	25.37	24.22	20.28	4.02	0.817
	1891.	Myrtle	27.24	33.71	18.43	5.44	1.003
		Lady	23.05	32.51	9.30	6.10	0.567
		Cedrica	25.73	34.91	13.84	5.09	0.704
		Madge	25.31	32.79	9.88	6.45	0.637
		Lyline	22.76	33.08	14.74	6.80	1.002
		Regia	22.23	23.02	8.34	5.45	0.454
		Deletta	19.43	27.25	10.06	6.35	0.639
		Misty	21.37	29.80	10.60	6.05	0.641
Jerseys		Average	23.40	30.88	11.90	5.93	0.706
	1892.	Myrtle	24.91	28.93	19.41	5.17	1.003
		Regia	21.52	21.61	10.47	5.60	0.586
		Cedrica	24.23	29.26	11.68	5.07	0.592
		Madge	24.14	27.59	11.80	6.52	0.769
		Lyline	25.80	32.37	22.41	4.70	1.053
		Etta	27.10	27.88	18.17	3.87	0.703
		Maid	20.82	26.52	13.23	4.97	0.657
		Average	24.07	27.59	15.31	5.00	0.766

In the general summary of Table X we find that the cows averaged about six and one-half years old and had been giving milk for an average of six months at the middle of each test. The average production of milk was sixty-nine pounds for one hundred pounds of dry matter consumed in the food, and the average production of butter-fat was three and one-fifth pounds per hundred pounds of dry matter in the food. Some of the cows lost in live weight while others gained; the average net gain for the thirty-one cows being a little less than one-tenth pound per day.

If we compare the figures giving the production of butter-fat with those showing the gain or loss in live weight we shall find that as a rule the live weight increased when the production of butter-fat fell below the average, and that there was a falling off in live weight when the butter-fat exceeded the average. The exceptions to this rule are chiefly found in the figures for 1891, and there is reason to believe that had the milk analyses in 1891 been as accurate as those in 1892 there would have been fewer exceptions to the rule noted. We find in 1892, however, that the Jersey cow, Myrtle, showed a considerable increase in live weight while producing a considerable excess of butter-fat, and we have no reason to doubt the analysis in this case.

Examining the figures more in detail, we find that eighteen cows showed a gain in live weight, the average gain being 0.354, or one-third pound per cow per day; the butter-fat production of these eighteen cows averaging 3.06 pounds per hundred pounds of dry matter in the food. Twelve cows lost in live weight during the test, the average loss being 0.300 pounds per day, and these cows produced an average of 3.47 pounds of butter-fat for each hundred pounds of dry matter in the food.

The average butter-fat production of all the cows was 3.20 pounds of butter-fat per hundred pounds of dry matter in the food;* but at this rate of production there was a small gain in live weight, hence the average limit of butter-fat production, above which there was a loss in live weight and below which a gain, was somewhat higher than 3.20 pounds per hundred of dry matter. In these experiments this average limit was about 3.25 pounds per hundred of dry matter, although several cows which showed a lower butter-fat production also lost in weight, while the higher production of butter-fat was not always attended with falling off in weight.

In the annual report of the Wisconsin Experiment Station for 1892, page 66, is given a table showing the amount of milk and butter-fat produced by one hundred pounds of dry matter in the food of sixteen cows, mostly grade Jerseys, which had been fed through a total period of thirteen weeks, from December 28, 1891, to March 28, 1892, the daily ration

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The cows consumed an average of 24.68 pounds of dry matter each per day, and the production of butter-fat was 0.792 pounds per cow per day, equivalent to nearly one pound of butter per day, calculating eighty pounds of the dry fat shown by the Babcock test as equivalent to one pound of butter with its normal proportion of water.

consisting of three pounds of ground oats, two pounds of shorts and four pounds of hay per day, with corn silage *ad libitum*. From that table, and from unpublished data kindly furnished by Prof. F. W. Woll, under whose supervision the experiment was executed, we have compiled the following table for comparison with Table X:

TABLE XI.—PRODUCTIVE CAPACITY OF DIFFERENT COWS AT WISCONSIN EXPERIMENT STATION.

Cow.	Age.	Days since calving.	Produced by 100 pounds dry matter in food.		Daily gain or loss in live weight.		Breed.
			Milk.	Butter-fat.	Gain.	Loss.	
	Years.	*Days.*	*Pounds*	*Pounds.*	*Pounds*	*Pounds*	
Mattie	10	105	80	2.35	0.389	....	Grade Holstein.
Emma	10	58	75	3.40	0.022	....	Grade Jersey.
Palmera	3	113	62	3.23	0.233	....	"
Rosetta	4	142	36	1.90	0.656	....	High grade Jersey.
Daisy 2d	6	135	64	3.55	0.778	....	"
Rue	8	79	55	3.05	0.467	....	Registered Jersey.
Daisy	10	70	84	4.05	....	0.122	Grade Jersey.
Bessine	6	24	95	4.70	....	0.167	High grade Jersey.
Beauty	11	94	80	3.05	....	0.300	Native.
Bunn	8	147	74	2.30	0.622	....	Holstein-Jersey.
Gay	9	128	56	2.40	0.367	....	Grade Jersey.
Galena	8	146	73	3.50	0.378	....	High grade Jersey.
Sylvia	10	132	67	3.50	....	0.256	Grade Jersey.
Bessie 2d	6	144	60	3.30	0.300	....	High grade Jersey.
Sylvan	4	102	45	2.77	0.567	....	"
Bryant	6	35	98	4.40	0.022	....	"
Average	7.4	103	69	3.22	0.247	....	

It appears that one hundred pounds of dry matter in the food produced in the average exactly the same quantity of milk and within six-tenths of one per cent. of the same quantity of butter-fat when fed to these Wisconsin grade Jerseys that it did when fed to our Ohio grade Shorthorns and registered Jerseys; while the average increase in live weight per day of the Wisconsin grade Jerseys was almost identical with that of the Ohio registered Jerseys (see Table VIII). It may be added that the average consumption of dry matter per day in the Wisconsin herd was 24.61 pounds per cow, as against 24.68 pounds in the Ohio herd, the average live weight for the Wisconsin herd being 872 pounds and for the Ohio herd 908 pounds.

It will be observed that twelve of the Wisconsin cows gained in weight during the test, while four lost in weight. The average gain in weight of the twelve cows was 0.400 pound each per day (against 0.354 pound in the Ohio tests), and the average butter-fat production of these twelve cows was 3.01 pounds per hundred pounds of dry matter consumed (against 3.06 pounds in the Ohio tests). Four of the Wisconsin

cows lost in weight at the rate of 0.211 pound each per day, and at the same time produced butter-fat at the rate of 3.82 pounds per hundred pounds of dry matter in the food. Twelve Ohio cows lost in weight at an average rate of 0.300 pound each per day, and deposited butter-fat at the rate of 3.47 pounds per hundred of dry matter. The discrepancy here between the average results of the two tests is greater than at any other point; but if the Jerseys only in the Ohio test were used in the comparison the figures would be 0.162 for loss in weight and 3.92 for production of butter-fat.

In the annual report of the New York State Agricultural Experiment Station for 1891 is recorded the produce during the first period of lactation of fourteen registered cows, including one Holstein-Friesian, four Ayrshires, three Jerseys, two American Holderness, two Guernseys and two Devons. From these records we have compiled the statistics for the ten months following the month in which the calf was dropped, and it appears that the cows consumed on the average 23.70 pounds of dry matter each per day and produced 3.03 pounds of butter-fat per hundred pounds of dry matter in the food. The average age of the cows at beginning of lactation was 821 days and the average live weight was 775 pounds. During the earlier months of this period half the cows lost in live weight; but this loss was gradually regained, and by the tenth month all the cows, except one, were heavier than during the second month, the average gain being at the rate of .28 pound per cow per day over the entire period.

In this experiment the cows were so fed that they received more fat in the food than they produced in the milk; but in the other experiment noted this was not the case.

According to our analyses the average ration fed to our cows in 1892 had the following composition in total dry matter, protein and crude fat:

TABLE XII.—DAILY CONSUMPTION OF PROTEIN AND FAT.

Feeding stuff.	Quantity eaten per day.	Total dry matter.	Total protein.	Total fat.
	Pounds.	*Pounds.*	*Pounds*	*Pounds.*
Blue grass hay	14.51	13.64	1.16	0.31
Corn silage	11.96	3.34	0.07	0.11
Mangels	25.00	2.40	0.04	0.04
Meals	6.00	5.30	1.15	0.29
Total		24.68	2.42	0.75

The cows received on the average, therefore, 0.75 pound of crude fat per cow per day in the food, while 0.79 pound per day was found in the milk, the live weight at the same time showing an increase. In other words, more fat was found in the milk than the total quantity given in the food, thus showing that while the fat of the food may be one of the sources of the fat of the milk there must also be other sources. The researches of German experimenters have shown that the protein of the food is one of the chief sources of the fat of the milk, while it is possible that the starchy matters also may be drawn upon in milk-fat production. It would seem reasonable to suppose, however, that the transposition of the fat of the food into milk-fat would take place before the more complex operation of fat formation from other sources would be undertaken, and therefore that a food rich in fat would produce a relatively larger quantity of milk-fat than one deficient in fat.

It happens that most of the feeding stuffs in ordinary use which are rich in protein are also rich in fat, and *vice versa*, a fact which increases the difficulty of determining experimentally which of these two food elements is the more servicable in fat production and at the same time make such determination of less practical value.

III.—THE RATIO BETWEEN INCREASE OF LIVE WEIGHT AND PRODUCTION OF BUTTER-FAT.

These experiments clearly show that with the same food and under the same treatment the vital machinery of one cow may transform into butter-fat an amount of fat equivalent to all that is found in the food; another may supplement this with fat previously stored up in the body, and still another may convert into butter-fat other constituents of the food than its fat, while others may divert the fat of the food into the formation of body-fat rather than butter-fat.

In measuring the total efficiency of a food or the total capacity of a cow, therefore, we must find some factor by which the increase of live weight may be compared with the production either of butter-fat or total milk solids, and until it can be demonstrated that one food may be more effective than another in the production of milk as against live weight we must use this factor in calculating the value of a food as a milk producer alone.

These experiments show that such a factor can only be deduced with safety from the study of a very large number of individuals, and this study should include the results of feeding for beef alone, as in such feeding the disturbing factor of milk production is eliminated.

In Table XIII we have compiled the results of such recent experiments in steer feeding as contain the data necessary for comparison with the experiments in cow feeding previously considered:

TABLE XIII.—PRODUCTIVITY OF FOOD IN STEER FEEDING.

Station.	Number of steers in test.	Age at end of test.	Gain in live weight. Per day.	Gain in live weight. Per 100 lbs. dry matter fed.	Reference.
		Years.	*Pounds.*	*Pounds.*	
Massachusetts	7	1	1.36	9.24	Ann. Rpts. 1891 & 1892.
"	7	2	1.45	7.65	" "
New York State....	5	1½	1.27	11.29	" 1890.
Virginia...............	12	3	2.17	9.26	Bulletin 10.
Ontario................	6	2	1.48	11.13	Exp. Farms. Rpt. 1891.
Kansas........	8	8	2.50	10.00	Bulletin 34 and 39.*
Maryland.............	4	3	2.78	11.60	" 22.
Iowa..	18	1	2.48	11.35	" 20. †
"	18	2	3.03	9.55	" "
Average..............	....	....	....	10.06	....

* Dry matter estimated from Jenkins and Winton's tables, and comparison made with lots fed on balanced rations only.

† Dry matter estimated from Jenkins and Winton's tables. These steers and five of the Massachusetts steers were fed through two successive winters.

In the Kansas and Maryland experiments other steers, fed on a less perfect ration, or under exposure to the weather, made a considerably smaller gain than that given in the table, but gain made under such conditions is not comparable with that made by well-sheltered and well-fed cows.

The results of these tests, when examined in detail, indicate as great a range of individuality in beef production as has been shown in milk production, and they forcibly demonstrate the necessity for accumulating a large number of observations before attempting to formulate any general law. In the general average it appears that the increase in live weight per 100 pounds of dry matter fed to steers, has been about three times as great as the production of butter-fat from the same quantity and kind of feed fed to cows giving milk.

This ratio of three pounds increase in live weight to one of butter-fat, must be accepted as true in a general way only. We know that it requires less food to produce a pound of live weight at the beginning than at the end of the fattening period, and in general that the quantity of food required increases with the age of the animal; we know, also, that it requires less food to produce a pound of butter-fat at the beginning than at the end of the period of lactation; we know that there is an increased tendency to substitute flesh production for production of butter-

fat as lactation progresses, but we do not know the ratio in which this substitution takes place. As a contribution to this knowledge the following tables are offered: In Table XIV the thirty-one cows employed in the Wisconsin experiment and the Ohio experiment of 1892 are arranged by classes, according to their distance from calving, and the "total product" is found by estimating the daily gain or loss of live weight on the basis of three pounds to one of butter-fat:

TABLE XIV.—EFFECT OF ADVANCE IN LACTATION ON PRODUCTIVITY OF FOOD.

Distance from calving.	No. of cows.	Butter-fat per 100 lbs. dry matter.	Live weight.		Total per 100 lbs. dry matter.
			Gain.	Loss.	
		Pounds.	*Pounds*	*Pounds*	*Pounds.*
Less than 60 days, average 39 days	3	4.16	....	0.04	4.11
60 to 120 days, average 91 days	9	3.32	0.11	....	3.47
120 to 180 days, average 142 days	13	3.05	0.27	....	3.41
More than 180 days, average 256 days	6	2.90	0.34	....	3.35

In Table XV the same cows are arranged by ages, but in this table both Ohio experiments are included:

TABLE XV.—EFFECT OF AGE OF COW ON PRODUCTIVITY OF FOOD.

Age.	No. of cows.	Days since calving.	Butter-fat per 100 lbs. dry matter.	Live weight.		Total product per 100 lbs. dry matter.
				Gain.	Loss.	
			Pounds.	*Pounds*	*Pounds*	*Pounds.*
3 and 4 years	7	127	2.95	33	....	3.40
5 years	7	260	2.99	23	....	3.30
6 years	10	135	3.45	29	....	3.83
7 years	6	157	3.62	....	11	3.47
8 years	4	115	3.14	28	....	3.52
9 years	5	172	3.05	....	12	2.93
10 years	6	105	3.22	....	9	3.10
11 and 13 years	2	133	2.75	....	15	2.55

This table indicates a stronger tendency to increase of live weight in the younger cows, and to milk production in those from six to nine years of age, with a decrease in total productiveness after the eighth year.

In Table XVI is given the average record of the fourteen New York cows during the first ten full months of their first milking period:

TABLE XVI.—EFFECT OF ADVANCE IN LACTATION ON PRODUCTIVITY OF FOOD.

Month of lactation	2	3	4	5	6	7	8	9 [1]	10 [2]	11 [3]
Butter-fat per 100 pounds dry matter	*Lbs.* 3.90	*Lbs.* 3.53	*Lbs.* 3.18	*Lbs.* 3.05	*Lbs.* 2.88	*Lbs.* 3.01	*Lbs.* 2.79	*Lbs.* 2.85	*Lbs.* 2.77	*Lbs.* 2.67
Daily gain or loss (——) in weight	....	–.37	–.07	.02	.16	.17	.22	.23	.29	.28
Total productivity of food.	....	3.04	3.09	3.08	3.09	3.24	3.08	3.16	3.16	3.04

(1) 13 cows. (2) 12 cows. (3) 10 cows.

It appears that in the case of these young and still growing cows there was an almost exact compensation between the fluctuations in butter-fat production and live-weight increase, on the hypothesis that three pounds of increase in live weight may take the place of one pound production of butter-fat; but the older cows, used in the Wisconsin and Ohio tests, manifest a loss of productiveness of butter-fat as lactation progresses, which is not fully compensated by the increase in live weight, as reckoned on this basis.

In Table XVII we have compiled the general results of the great Chicago test, as published in the *Breeders' Gazette*, using Jenkins and Wintons' averages for determination of dry matter except for corn silage, for which we have estimated 25 per cent. dry matter:

TABLE XVII.—SUMMARY OF THE CHICAGO TEST.

Breed.	Dry matter consumed per day per cow.	Butter-fat produced per day per cow.	Butter-fat per 100 lbs., dry matter.	Gain in live weight per day per cow.	Total product per 100 lbs. dry matter.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Jersey	30.00	1.56	5.20	0.34	5.58
Guernsey	26.70	1.24	4.63	0.21	4.89
Short-horn	31.30	1.12	3.56	1.31	4.95

If we may assume that the difference between Jerseys and Shorthorns lies simply in the kind of product realized from their food, and not in its total quantity, it would seem that the ratio of three pounds increase of live weight to one of butter-fat is too high for comparison in this list. Apparently, the ratio was nearer two to one than three to one.

These cows were in the average about 85 days from calving at the middle of the test, as compared with 103 days for the Wisconsin cows, and 180 days for the Ohio cows.

The two most powerful impulses governing the vital forces are the one which makes for growth until the age of maturity is reached and the one which causes even growth to stop temporarily when lactation begins, and which, under an insufficient supply of food, may cause the previously built up tissues to be drawn upon to the point of emaciation in order to keep up the flow of milk. Table XVI shows how these forces may war against each other, the tendency toward milk production (which is simply a manifestation of the reproductive impulse) for a time overcomes all other forces, and the live weight falls for several months; but finally the two impulses balance each other and then shortly the tendency to growth resumes sway.

In the Wisconsin test the ratio of complete substitution was about three to one. In the average of the two Ohio tests the younger Jerseys showed a more general tendency to increase in live weight than the older grades, but this increase was made at a higher food cost with the Jerseys than with the grades, as the average rate of substitution was about two to one for the Jerseys against twelve to one for the grades. Apparently, in dealing with this question we have to deal not only with the impulses towards growth and reproduction, but age and breed are also important factors in determining the ratio between butter-fat production and increase of live weight.

CONCLUSIONS.

The foregoing study of experimental data shows that very great differences may exist between the ability of different animals to utilize the food given them in the production of butter-fat or increase of live weight.

It justifies the expectation, however, that when more complete and perfect data are obtained it will be found that these forms of productive energy may replace each other under a general average ratio of about three pounds of increase in live weight to one pound in yield of butter-fat.

It indicates that this ratio may be temporarily modified by age, by advancement in lactation or in fattening, and by breed; but that the average increase in live weight over the entire period of fattening and the average production of butter-fat through entire periods of lactation, as well as the average gain or loss in live weight during lactation, may be compared upon this basis with a relatively small margin of error.

IV.—POSSIBLE IMPROVEMENTS IN MILK PRODUCTION.

In apportioning the grain and coarser feeds in the rations used in the experiments under consideration, the ordinary practice of farmers and dairymen has been followed of giving the larger proportion of the food in the form of hay and corn fodders, and it is probable that the results indicate very closely the average outcome of this practice, and that it is safe to assume the production of butter-fat for 100 pounds of dry matter fed to the dairy cattle of the country as not exceeding the amount realized in these tests, or three pounds, equivalent to a little less than four pounds of butter.

Two possible lines of improvement on this yield are suggested by these tests: (1) By the selection of cows of greater productive capacity than the average, and (2) by increasing the proportion of fat or protein, one or both, in the food. In the first line much has already been accomplished in the establishment of butter-making breeds; but our experiments show that registry in the herd books is not alone a sufficient guaranty of superiority at the butter tub. In the second line valuable work has been done under the stimulus of competitive dairy tests, but the difficulty encountered here is the great danger of impairing the health of the animal by excessive feeding.

In both these lines the great test at Chicago offers valuable evidence. In this test the seventy-four cows were fed for ninety days at the rate of about 29.4 pounds dry matter per cow per day, on which they produced an average yield of 4.45 pounds of butter-fat per hundred pounds of dry matter in the food, and at the same time increased in average live weight at the rate of nearly six-tenths of a pound per cow per day. This is an average increase of nearly fifty per cent. over the results attained in the experiments under consideration, and this increase seems to have been accomplished chiefly through the two lines suggested. The herds of the entire United States and Canada were drawn upon to furnish animals for the test, and the average ration was so proportioned that it contained 1.54 pound of fat and 4.60 pounds of protein per cow per day, or more than double the quantity of each contained in the food consumed by our cows. The total fat given in the food was considerably in excess of that carried off in the milk, whereas in our test and the others noted (except that of the New York station), it was considerably below that quantity. This was accomplished by high feeding on rich grains, the average grain ration per cow per day amounting to 18¼ pounds, containing fully sixteen pounds of dry matter.

The cost of the grains used in this Chicago test averaged nearly fifteen dollars per ton and that of the hay was estimated at ten dollars. The percentage of dry matter in the hay and in the grain was probably approximately the same. On this basis, the cost of 100 pounds of dry matter in the mixed ration as fed at Chicago was about seventy-four cents,

whereas the cost of the same quantity of dry matter fed in the Ohio and Wisconsin tests was about sixty-three cents. If we estimate butter at twenty cents per pound, or butter-fat at twenty-five cents, and increase the live weight at five cents, the total value of the product of 100 pounds of dry matter as fed at Chicago was $1.14, and as fed in Ohio and Wisconsin it was eighty-one cents. The net value, therefore, was forty cents at Chicago and eighteen cents in Ohio and Wisconsin—a difference of more than 100 per cent. in the net profit in favor of the results at Chicago.

There is, however, one other factor which must be considered in comparing the results attained at Chicago with those shown in the other tests under consideration, namely: Distance from calving. In the case of the cows used in the Chicago test the average time between calving and the middle of the test was about eighty-five days, as against 103 days with the Wisconsin cows and 180 days with the Ohio cows.

During the first of these periods the Wisconsin cows were approximately the same average distance from calving as those at Chicago, but their average fat product per 100 pounds of dry matter was still nearly thirty per cent. below that at Chicago, and the net profit on their feed was but sixty per cent. of that realized at Chicago.

The Chicago test therefore must stand as a goal of possible achievement far in advance of average results. The experiments here discussed serve to measure the distance between average production and this goal, and at the same time demonstrate the possibility of attaining it, for several cows in the herds under consideration have closely approached the average of the Chicago cows in their work.

PRACTICAL APPLICATIONS AND SUGGESTIONS.

The question of the relative food cost of butter-fat and beef, as applied to the feeding of dairy cows or fattening cattle is one of great importance to the farmer and dairyman; for upon it may depend the entire system of farm management.

The question of the play between butter-fat and live weight is perhaps of greater interest to the investigator than to the practical dairyman, although even he cannot afford to be ignorant of the laws governing it. That the investigator cannot afford to ignore it is sufficiently shown by any one of the experiments here quoted, but more conspicuously, perhaps, by the Chicago test than any other. In view of these results it would seem to be a case not admitting of argument that neither a test comparing different foods nor one comparing different breeds can be conclusive unless this factor is given its due weight.

The general average value of this factor, as suggested in preceding pages of this bulletin, must be regarded as tentative only, and subject to the modifications which further experience will dictate. Until the per-

fection of the Babcock method for determining fat in milk, it was practically impossible to accumulate the immense number of observations from which only such a value can be deduced, but with that test at hand and the facilities for chemical analysis now possessed by every experiment station it is not unreasonable to expect that our knowledge on this and similar points will soon be greatly enlarged.

The bulletins of our American experiment stations contain reports of many carefully made experiments in the feeding of dairy cows, but only in those mentioned in this bulletin have we found the complete data necessary for the study of this problem. The Babcock test is being generally used, and percentages and daily yields of butter-fat are becoming abundant; but variations in live weight and composition of food have seldom been reported with the fullness and exactness required for this work. In some cases the variations in live weight have not been observed; in others they have been estimated from single weighings, made one each month; but it is a well established fact that single cows may vary in weight fifty pounds or more between two days, and our experiments show that entire herds may go up and down in the same manner. In some experiments the dry matter in the food is estimated on the basis of Jenkins and Winton's averages instead of special analysis. Undoubtedly these averages are very close approximations to the truth for most feeding stuffs; but in the case of corn silage they are largely based upon the earlier analyses of silage made from immature corn, and they are entirely too low for such silage as is now in most common use—that made from corn carrying a considerable percentage of grain and harvested but little before the point of full maturity. On this point we quote a few of the more recent analyses of corn silage:

TABLE XVIII.—ANALYSES OF CORN SILAGE.

Station.	Publication.	Per cent. dry matter.	Remarks.
New York state.............	Annual Rpt. 1891, p. 40...	23.86	Av. of 7 analyses.
Pa. state college	" " p. 23...	23.07	" 2 "
University of Wisconsin	" " p. 54...	27.47	....
" "	" " p. 220..	27.49	....
" "	" 1892, p. 60...	35.31	Made from mature field corn...........
Ohio State Exp. Sta........	B, June, 1890, p. 155......	25.92	Av. of 5 analyses...
" "	Current issue...............	26.33	" 2 "
Jenkins & Winton's av....	U. S. Dpt. Agricult're Ex. Stat. Bull. No. 11	20.90	....
" " min		12.30	....
" " max		37.60	....

There is opportunity for wider variation in the percentage of dry matter in silage than in almost any other feeding stuff in common use, and as the dry matter must form the basis of any comparison of foods it is highly important that it be carefully determined.

As we review our own work we regret that the number of analyses, not only of silage but of the other feeding stuffs used, and of the milk, could not have been multiplied many times.

WORK NEEDED.

The experiments under review furnish useful indications on the questions they were designed to illustrate, but their greatest value consists in their demonstration of what is needed in order to increase our fund of exact knowledge.

The necessity for dealing with large numbers of individuals in the study of questions pertaining to animal life and nutrition is exemplified in every test under review. It would seem that experiments including two or three individuals only are scarcely worth the making.

The necessity for extending these tests over the longest possible period of time is shown. We need to expand the 90-day test into a 12-month test, and the 12-month test must grow into observations extending over the entire lifetime of a very large number of individuals before perfection in this work is attained. We might as well drop the three or four-week test altogether.

The value of exact chemical analyses is fully shown, and the necessity for endless repetition in such analyses.

The relation of meteorological conditions to vital processes needs careful study.

All these points are simply matters of method, the ultimate end of which should be to ascertain the laws under which the vital forces work. To work persistently with this end in view is not at all inconsistent with securing immediate but incidental results of practical application on the farm. On the contrary, the value of these practical results will depend altogether upon the faithfulness with which we follow the scientific ideal.

SUMMARY.

I. Our contrast of corn silage and field beets as food for milk production leads to the following conclusions:

1. The feeding of beets to milk cows has already increased the consumption of other foods and of total dry matter.

2. Beets have always produced an increase in the flow of milk and in the total yield of butter-fat, but this increase has never been sufficient to offset the additional consumption of food.

3. The cows have always shown a greater average live weight while feeding on beets. A part of this increase was probably due to increased weight of the contents of the digestive tract, but a part seems to have been actual gain.

4. Beets have not diminished the amount of water drank, although fed in such quantity as to increase the watery contents of the food by thirty pounds per day.

5. Our experiments do not justify the assumption that the dry matter of beets is any more effective as a cattle food, pound for pound, than the dry matter of silage made from well matured corn containing thirteen to eighteen per cent of grain.

6. In the region where the tests were made, and as the average of ten years' culture of corn and beets, side by side, two pounds of dry matter have been produced in the form of corn silage at a less cost than one pound of dry matter in the form of beets.

7. A question which our experiments suggest, but do not answer, is whether beets may be used with any greater advantage in comparatively small quantity and simply as appetizers.

8. While silage made from comparatively mature corn has shown the best results in general, our experiments suggest that the silage should be made before the corn has reached full maturity.

II. The results of our study of the comparative productive capacity of different cows are as follows:

1. When fed a ration composed of about one-fifth to one-fourth grains and the remainder coarse foods of good quality, our cows and those of several other stations have produced an average of about three and one-fifth pounds of butter-fat to each hundred pounds of dry matter in the food, besides making a small gain in live weight.

2. In general, when this rate of production of butter-fat has been exceeded there has been a loss in live weight, and when the butter-fat has fallen below this rate there has been a gain in live weight.

3. Individual exceptions to this general rule show that while some cows may return a handsome profit on their food, others may be fed at an actual loss, even when both butter-fat and increase of live weight are counted at full value.

III. From a comparison of experiments made by several different stations we conclude that in the general average, full periods of fattening

being compared with full periods of lactation, the increase in live weight from a given quantity of food seems to be about three times as great as the average yield of butter-fat from the same quantity of food; and that in the case of cows giving milk, increase in live weight may replace yield of butter-fat in the same general ratio, modified by age, breed and advancement in lactation.

IV. The superior productiveness of individual cows employed in the World's Fair test at Chicago demonstrates the possibility of achieving a great increase in average productiveness through intelligent selection and better feeding.

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MISCELLANEOUS ENTOMOLOGICAL PAPERS.

BY F. M. WEBSTER.

THE ASPARAGUS BEETLE.

Crioceris asparagi Linn.

ORD. COLEOPTERA: Fam. CHRYSOMELIDÆ.

The species was described by Linnæus[1] in 1796 as a *Cryptocephalus*, the habitat being given as Europe, but the statement is made that gardeners thought it to have been brought from Russia, though Fr. Th. Keppen[2] states that it is sometimes common in that country and the Caucasus, but never proves destructive. As asparagus is indigenous in some portions of Asia, and in Europe about the Mediterranean, and was cultivated prior to the Christian Era, therefore we may expect the insect to have been rather an ancient depredator of this plant.

FIG. 1. Stalk with eggs attached: adult and larva. Lines beneath indicate natural length. After Lintner.

It was first observed in this country at Astoria, near the western end of Long Island, New York, in 1859, and not unlikely occurred sparingly about New York City a year or so earlier, having been introduced from Europe, or England where it had also occurred for many years. Mr. Robert E. Mathewson, in his special Report on Insects, Fungi and Weeds Injurious to Farm Crops, p. 12, 1889, says there is no record of its appearance in Ireland.

[1]Faun. Suec. Ed. I, p. 151; Ed. II, p. 172.

[2]Obnoxious Insects of Russia, Fr. Th. Keppen, p. 273, 1880.

Miss Ormerod, however, states that it has been known in England for about 40 years.

Its spread over the eastern United States has not been rapid, as it has so far only extended permanently, south to Virginia and West to Cleveland, Ohio. Professor Claypole, of Akron, tells me it occurred at Salem, Columbiana county, some six years ago. This county borders on Pennsylvania, and is at the point where the Ohio river begins to form the boundary line between the two states. As I do not hear of the species elsewhere along the lake shore, the inference is that it was first brought down the Allegheny river from New York and thence into the Ohio, though Dr. Hamilton, an old and experienced collector about the junction of this stream, where it begins to form the Ohio, has never found it in his locality. It will most likely spread slowly westward over this State, but just now seems to keep well to the northward.

Mr. A. Bolter, an old and experienced collector of Chicago, however, informs me that he captured five specimens of the beetle, near that city, about twenty-five years ago, but has not observed the species since. He, has specimens collected by the late Mr. B. D. Walsh, at Rock Island, Illinois. Mr. Walsh died November 18th, 1869. As far as I am aware, these collections have never before been placed on record, and the species was not known to occur further west than eastern Ohio. As now appears, it has once before been introduced into the west and disappeared, the present being, probably, a second invasion, and one that has the appearance of having come to stay.

Description of the Various Stages.

These I shall copy from Dr. Lintner's carefully written statement in his first Report:

"The Beetle.—The beetle is a very pretty insect in its trim form, contrasting colors of yellow, red and shining-black, and its conspicuous ornamentation. Its average length is a little less than one-fourth of an inch. The head is black, with the first three joints of the short antennæ smaller and differently colored from the remainder. The finely punctured thorax is tawny-red, marked more or less distinctly on its crown with two black spots. The wing-covers are punctured in rows, and usually appear of a lemon color, broken into three spots on each, as in the accompanying figure 2, by a black stripe along their junction, a black transverse band a little behind their middle, and an interrupted one near their tips. Outwardly the wing covers are bordered with orange. The body beneath and the legs are shining black, the latter sometimes showing a yellowish band upon them. Examples having the wing-covers marked as above, suggest the representation of a black cross upon the back, for which reason it is sometimes known in England as the 'cross-bearer.'"

"In some of the beetles the wing-covers may be described as blue-black, with an orange margin on the sides and at the tip, and above with six small yellow spots.

FIG 2. Asparagus beetle with section of foot and antenna enlarged After Lintner.

Fig. 2, from examples received from a market in New York city, is the variety which Dr. Fitch seems to have had before him for his careful description. Along the middle of each wing-cover is a row of three lemon-yellow spots. The anterior one of these is placed upon the base of the wing-cover, and is usually egg-shaped with its pointed end directed backward. The middle spot is placed at a third of the distance from the base to the tip of the wing-cover. It is transverse, being a third more broad than long, and is thicker toward its inner end, which terminates at the third row of punctures from the suture, its opposite or outer end being confluent with the orange border. The hind spot is placed nearer to the middle spot than to the widened orange tip of the wing-cover. It is similar in most respects to the middle spot, but is frequently smaller and placed somewhat obliquely, its inner end inclining backward, and its outer end uniting with the orange border by a narrow neck."

"The above variety would hardly be recognized as indentical with the form usually figured. The elytral spots have been described in general terms as very variable in shape and size. Fitch notes their great variation. It is interesting to find that such marked variation in individuals can co-exist with such permanency of feature, that the pattern so minutely described by Dr. Fitch is exactly that shown by the example figured from my collection."

"*The Larva.*—The young larva and the mature form are represented upon the upper portion of the stem, and on the left in the figure 1, it is given enlarged. Its greatest length is about one-fourth of an inch.. 'It is of an obscure olive or dull ash-gray color, often with a blackish stripe along the middle of the back. It is soft and of a flesh-like consistency, about three times as long as thick, thickest back of the middle, with the body much wrinkled transversely. The head is black and shining, and the neck, which is thicker than the head, has two shining black spots above. Three pairs of legs are placed anteriorly upon the breast, and are of the same shining black color with the head. As will be seen when it is crawling, the larva clings also with the tip end of the body; and all along its under side may then be seen two rows of small tubercles, slightly projecting from the surface, which serve as prolegs in addition to the tip of its body. Above these tubercles on each side is a row of elevated shining dots like warts, above which the breathing pores appear like a row of minute black dots.' (Fitch.)"

"*The Egg.*—The eggs of the beetle are of the size and form shown at the middle of Fig. 3. At the right, they are given in enlargement. Their color is blackish-brown. They are placed on end on the young plant, usually in rows of from two to seven. When the plants are grown, the eggs are deposited on the leaves near the end of the delicate branches."

Life History.

"The history of *C. asparagi* is, in brief, as follows: The beetles destined to continue the species, survive the winter in dry, sheltered places, as beneath bark, in

FIG. 3. Larva eggs and adult of Asparagus Beetle. After Fitch.

crevices of wood, and under the clapboards of buildings. Simultaneously with the appearance of the asparagus shoots in early spring, they emerge from their winter quarters, and commence to feed upon the tips of the plants. The sexes pair, and the female deposits her eggs upon any portion of the exposed shoots. The eggs hatch in an average period of eight days. The larvæ eat voraciously and grow rapidly, so that they complete their growth in about twelve days. They then leave the plants and enter the earth for a short distance, or merely conceal themselves beneath dead leaves or other material on the surface. Constructing a slight cocoon, they undergo their transformation, and remain in their pupal state for about ten days. Thirty days complete the cycle from the egg to the perfect insect. Almost as soon as the beetles emerge, they pair, as the sexual instinct is strongly developed in them, as is shown in the frequency in which they come under our observation mated. The eggs are then deposited, and the beetles continue to feed upon the plants, eating holes into the bark of the more tender branches for several days; one was found by Dr. Fitch to feed for a fortnight in confinement. A second brood results from these, appearing about the first of July, followed by a third, probably in August. Hence we have the larvæ and the beetles with us, in their successive broods, through the spring and summer, into September."

Remedies and Preventives.

No practical measure for destroying this pest is known in Europe the best known being hand-picking. Dr. Fitch advised giving barnyard fowls range of the asparagus beds, in order that they might devour the pests.

"Mr. A. S. Fuller, of Ridgewood, N. J., has furnished to the American Entomologist, for January, 1880, a method for destroying this pest, which as it presents the result of his personal experience, seems to be all that is needed for the purpose. Shortly after its appearance on Long Island, it was discovered, according to Mr. Fuller, that freshly-slacked lime, scattered over the plants, would instantly kill every larva that it touched. The lime may be conveniently applied by using an old broom for a duster, or a Paris green sifter. With a pail full of dry lime, a man could in a short time dust an acre of asparagus. 'The lime is best applied in the morning while the dew is on, for then a portion will adhere to the plants as well as the grubs, and during the day or days following it will be constantly dropping down or blowing about among the leaves and branches, thereby making the escape of any of the larvæ all the more uncertain. * * * * * * For the past sixteen years, I have used lime as described, upon my asparagus beds, to keep the insect in question in check, and it has done it so effectually that about one application every alternate season has been sufficient' (Fuller). Not only is lime cheap and readily procurable everywhere, but it is also of benefit to the asparagus roots. It has also the additional merit as in insecticide, that it can be used upon the young plants while they are being cut for market, for the destruction of the first brood of larvæ, while Paris green or London purple may not safely be used."

According to Dr. Lintner:

"The Long Island gardeners have found great relief from the excessive ravages of this insect by cutting down in the spring at the time when the beetle is ready to deposit its eggs, all the young seedlings which are usually selected for

oviposition as well as for food, and thus forcing the beetles to deposit their eggs upon the new shoots. These being cut for market almost daily do not permit the eggs to hatch, and bv this means, the greater portion of what would be the second brood are destroyed."

In my own correspondence, I have always recommended Pyrethrum, to be used either mixed with flour, or in water in the proportion of one ounce to three gallons of water, and all reports of the effect have been favorable.

THE WESTERN CORN ROOT–WORM.

Diabrotica longicornis Say.

(FIGS. 4, 5, 6, 7, 8.)

Ord. COLEOPTERA: Fam. CHRYSOMELIDÆ.

During September, 1892, these beetles were received from Mr. W. C. Cone, of Sater, Hamilton county, with the complaint that they were injuring his sweet corn by eating the silk, before the kernel had been fertilized. This, so far as I am aware, is the first time the insect had been observed in Ohio in destructive numbers, if, indeed, it had been observed at all. Some correspondence, later in the season, revealed the fact that it was present in Van Wert county also, though not known to have done any damage. During August of the present year, a personal investigation showed the pest to be present in the corn fields of Putnam, Allen, Auglaize, Shelby, Miami, Montgomery, Butler and Hamilton counties, there being no doubt whatever of their presence in the counties bordering on Indiana. In fact, Mr. Giffin, of Van Wert, had personal knowledge of them as far north as Paulding. With an acquaintance with this pest covering a period of eighteen years, in both Illinois and Indiana, I was not a little concerned when I found it here in Ohio, this year, precisely as I did in Illinois, in 1875, and in about the same numbers; for, as will be seen from the subsequent history, within five years thereafter it began to be one of the worst pests of the cornfield, and there does not appear to be any reason why, if it is not vigorously taken in hand, the same may not prove true in Ohio.

The fully developed insect, Fig. 4, is a green or greenish yellow beetle about a quarter of any inch long and resembling in form the striped squash beetle, to which it is nearly related. This is the stage in which it is most likely to be noticed, though it is comparatively harmless.

FIG. 4. Adult.

These beetles may be found in the fields from the latter part of July until after the pollen has fallen and the silk becomes dry and brown, either on the tips of the ears, on the tassels, or among the mass of pollen that usually collects about the stalk at the bases of the upper leaves, this pollen and the silk being their principal food. When ready to oviposit, the female de-

scends into the ground about the roots of the corn and there lays a considerable number of minute, white eggs, Fig. 5, greatly enlarged, which to the unaided eye resemble grains of white sand. After doing this the insect dies.

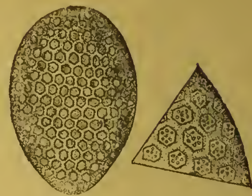

FIG 5. Egg greatly enlarged, with triangular section more highly magnified.

These eggs lie in the earth, apparently unaffected by climatic or such abnormal conditions, as overflow, etc., until the following spring or early summer, when they hatch out minute, active grubs, which at once begin to feed on the small fibrous roots of the corn, in case this crop has succeeded itself. Following these smaller roots and eating them entire, on reaching a larger one the worms change their mode of attack somewhat and now burrow parallel channels in them which often extend to the base of the plant itself. These channels seldom show from without, but on breaking the roots, the worm will be found as shown in Fig. 6. In cases of severe attack, late in the season, the brace roots will be found on examination to contain little besides the worms and their castings.

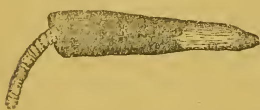

FIG. 6. Larva in root.

When full grown the worms are nearly white in color and of the form shown in Fig. 7, the length being a little less than one-half an inch, while in diameter they are about the size of an ordinary wheat straw immediately below the head. Often, where the soil is very rich and a good growth of stalk has been obtained, nearly every root will be amputated, leaving the plant to be blown over by the winds. In Illinois I have seen fields where there had been a stalk growth sufficient to have produced at least seventy-five bushels per acre, yet by the middle of August hardly a plant was standing upright, the remainder lying prostrate on the ground in every direction, the ears shriveled and worthless. Where soils are only of ordinary fertility or poor, the effect on the ear is to foreshorten it, in case of a light attack, and dwarf it to unproductiveness in more severe cases, while the stalk may or may not have made half its normal growth, the general result being almost the counterpart of that consequent upon impoverished soil combined with dry weather.

FIG. 7. Larva.

After reaching their growth in the worm stage these larvæ leave the roots, and crawling to one side, by working their bodies about construct an earthen cell wherein they transform into pupæ, in which condition they required no food. The pupa is also of a white color, and its form is indicated by Fig. 8, the line at the right indicating the natural length. After remaining in this state for a short time the pupæ transform to adult beetles, and these make their way to the surface and thence

FIG. 8 Pupa.

to the ears and tassels, or to the bases of the leaves, as has been previously stated, there being but a single generation each year.

Although provided with wings and amply capable of flying from one field to another, there is little disposition among them to travel about, and so long as the supply of fresh pollen and silk furnishes them food, the beetles are little apt to be observed outside the corn fields; and, as they do not appear until after the crop is laid by for the season, they may not attract attention even there. After forsaking the fields, they may be observed on thistles, golden rod and other late flowering plants, including clover. From what follows it appears that, under certain conditions, females that have not oviposited previously, may do so in these clover fields, and in case the succeeding crop is of corn, the larvæ work some injury the following year, though I think this is unusual.

The adult beetle was described in 1823 by Mr. Thomas Say, from specimens taken by him while connected with the Major Long expedition to the Rocky Mountains, and its habitat was given by him as the Arkansas Territory.[3]

No facts concerning the habits of this insect were recorded until the year 1866, when specimens of the beetles were referred to Mr. B. D. Walsh by Prof. W. S. Robertson, of Kansas, who found them in large numbers on Imphee or Sorghum, their natural home being a large thistle. Mr. Walsh, in acknowledging the receipt of the specimens, stated that he had taken three specimens many years before on flowers, in Central Illinois.[4] Eight years later, in August, 1874, Mr. H. Webber, of Kirkwood, Missouri, sent some larvæ and papæ to Prof. Riley, with the complaint that the former were burrowing into the roots of his corn, and doing considerable damage. In July, 1878, larvæ were again received by Prof. Riley,[5] this time from Mr. G. Pauls, of Eureka, Missouri,[6] and from these he reared adult beetles, on the 14th of the following month.

During the spring of 1874, the writer began to collect Coleoptera in the vicinity of Waterman, DeKalb county, Illinois; but during this and the two following years obtained only a single specimen. In September, 1877, quite a number of the beetles were taken in cornfields. Mr. Frederick Blanchard, the well-known coleopterist of Lowell, Massachusetts, at that time informed me that he possessed specimens from New York, Kansas and Central America. I have since seen specimens from Arizona, while Mr. Dury, of Cincinnati, has collected it in New Mexico. Mr. Ottomar Reinecke, of Buffalo, N. Y., recently wrote me that he collected the species about Buffalo prior to 1880, and found them in numbers on willow growing along the margin of a small creek, having never looked

[3]Journal Phil. Acad. Nat. Sciences, Vol. III, p. 460.

[4]Practical Entomologist, Vol. II, p. 10, 1866.

[5]American Entomologist, Vol. III, p. 247, 1880. (Note. See "Roots of Corn injured by some unknown insect." Am. Entomologist 1870, p. 275, Vol. 2.)

[6]Report Comm. Agr., 1878, p. 208.

for them elsewhere. It is, however, not included in the list of Coleoptera of Florida and Michigan by Messrs. Hubbard and Schwarz. The season of 1878, 1879, 1880, found the beetles occurring in increasing numbers in Illinois, so much so that in September, 1881, I was led to express the fear that they would prove a worse pest than the chinch bug;[7] fears that have since been fully realized in that locality.

The Western Rural (Chicago, Ill.), in its issue of May 18, 1879, contained a communication from "N. A.," of Swan Creek, Warren county, Illinois, who stated that for the last few years, cornfields in that section had been infested by a small, white worm, which, except in size, color and habits, resembled the yellow wire worm. But, instead of these worms attacking the kernels they entered the roots at the base of the stalk and burrowed under the bark of the roots, thereby destroying them.

In September, 1882, Mr. Wamock, whose fields near Mason City, Mason county, Illinois, were at that time seriously injured, stated to me that he had noticed the larvæ in corn for ten or twelve years previously, and remembered of serious damage being done at least seven years before. This statement was indorsed also by several other farmers in that neighborhood.[8]

"R. S. B." writing to the Prairie Farmer from LaSalle county, Illinois, states in the issue of that paper for September 7, 1880, that the pest had been known in that county for several years.

In July, 1880, the late Dr. E. R. Boardman, of Elmira, Stark county, Illinois, found great numbers of small white worms destroying both the fibrous and brace roots of corn, in fields in his vicinity.[9] Some of these larvæ were forwarded to Prof. G. H. French, at that time assistant State Entomologist, with the suggestion that they might belong to some species of Scarabæidæ. The damage being done by these worms, in some fields, amounted to one-third of the crop. The similarity of these larvæ to those of *Diabrotica vittata* led Prof. French, who had overlooked Prof. Riley's notice in the Report of the Commissioner of Agriculture for 1878, to suspect that they were of some species of that genus, and suggested to Dr. Boardman that such might be the case. To this the Doctor replied that *D. longicornis* was very abundant on the corn, and also the beetles had been very troublesome to vines that season—more so than *D. vittata*. On the 17th and 18th of the August following two adults of *D. longicornis* emerged from the larvæ sent by Dr. Boardman in July. A few days later he again writes Prof. French that the damage in many portions of Stark county, was quite serious, and also that he had been informed by Hon. J. H. Lewis, of Knox county, that serious loss had also been sustained in that section of the State. In this letter the Doctor observed that such fields as had been exempt from attack had the

[7]Eleventh Report State Entomologist of Illinois, pp. 68, 69.
[8]Twelfth Report State Entomologist of Illinois, p. 13.
[9]Loc. cit. Eleventh Report, p. 65: Prairie Farmer, Aug. 8, 1880.

previous season been in grass or sown to oats. Still, a few days later, he again wrote Prof. French that the adults were very abundant on the blossoms of *Ambrosia trifida*, and also they were devouring the silk on the ends of the ears of corn, probably before the kernels had been fertilized; and later they seemed to feed on the kernel itself. "R. S. B.," in his letter to the Prairie Farmer, previously quoted, stated that they not only ate off the silk at the end of the ear, but also some of the kernels, while the latter were in a soft state. Prof. French, in 1881, found adults in considerable numbers in his garden on black wax beans.

During the spring of 1882 Prof. S. A. Forbes, the then recently appointed State Entomologist of Illinois, with myself as his assistant, began a systematic study of this pest and its life history.[10] The species was found to occur generally in the fields of corn, from Centralia northwestward to DeKalb county—as far as examinations were made—and they were reported also in southeastern Iowa. The damage to the corn crop, by reason of the attacks of the larvæ, being variously estimated at from five to fifty per cent., with a few instances where the destruction was nearly total. Fields that had been planted after grass, or any of the smaller cereal grains, were not injured; but where the land had been devoted to corn for three years and upward, the loss was as previously estimated. And this was true even where the new and old grounds had been thrown into one field, and planted with the rows running transversely, as the old dividing line between the two former fields could be easily detected by the difference in the abundance of the larvæ about the roots of the corn. In a less marked degree the same difference could be detected in the relative number of adults.

The eggs were first observed by me near Normal, McLean county, Illinois, on the 18th of October; but the period during which oviposition takes place has never been exactly defined. From the fact that Dr. Boardman observed the adult beetles on June 25th in southeastern Iowa, and in Stark county, Illinois, on July 1st, while I found them quite abundant in 1886 about Lafayette, Indiana, a few days later, it would seem that oviposition should begin at least as early as August, while Prof. Forbes found females early in October with eggs still in their ovaries.[11]

The eggs have so far only been observed about the roots of corn, and while it seems probable that this is the place usually selected for oviposition, that the insect does not hesitate to place her eggs about the roots of other plants is apparent. As illustrations, Prof. Forbes finds the larvæ destroying corn in fields following crops of both broom-corn and sorgum,[12] while, during the fall of 1886, I received complaints from Mr. James McCleery, of Waterman, Illinois, and others in that section, stat-

[10]Twelfth Report State Entomologist of Illinois, pp. 10-31.

[11]Loc. cit. p. 25.

[12]Miscellaneous Essays, p. 20.

ing that the first crop of corn following a crop of clover had been seriously injured by the root-worms. Mr. Samuel Dragoo, of Macedonia, Indiana, also states that they injured one of his fields, that was previously in timothy and clover and pastured, but both of these latter statements were unverified by specimens.[13]

When found about the roots of corn, the eggs are from one to five inches from the surface of the ground, and scattered about loosely in cracks and crevices, wherever a cavity is offered in which to place them, the female evidently taking no pains to protect or secrete them. In some instances, the dead body of the female will be found in such places among the roots, in the midst of her eggs. While the larvæ have never been reared from eggs found in such localities, a comparison of a great number by Prof. Forbes, including those first discovered by me, with others taken from the ovaries of females, showed conclusively that they were identical.

The exact time when the eggs hatch is not known, but the larvæ are found in the ground from June to August. Their appearance, as indicated by the effect upon the growth of the corn, in all probability does not occur earlier than June. Their food, so far as has been observed, consists of the roots of corn, but Dr. Boardman states that he has observed them in the roots of rag-weed, while Mr. D. S. Harris, of Cuba, Illinois, makes a similar statement; and adds that he found them also on the stems of garden purslane, *Portulaca oleracea*, and the roots of lamb's quarter, *Chenopodium album*.[14]

The adult beetles were observed as previously stated by Dr. Boardman on June 25th in southeastern Iowa. The same gentleman reports them flying in Stark county, Illinois, as late as November 9th, and thinks he has observed them under rubbish as late as December,[15] while I observed them in De Kalb county, Illinois, as late as early in November, among shocked corn. No one however is known to have observed them early enough in the season to indicate a possibility of their having hibernated in this stage. Their food, as studied by Prof. Forbes, consists of the pollen of corn, thistle, smart-weed, rag-weed, clover, corn, both kernel and silk, spores of fungi, and fragments of the petals of clover. Several of these had been recorded previously by others.[16] To this list must be added beans, on the authority of Prof. French,[17] cucumber and squash vines, on the authority of Dr. Boardman.[18] Besides, we have observed them feeding upon the flowers of compositæ, helianthus and cotton, the pollen of the squash, and on that of sorgum; while Mr. Sidney Lat-

[13]Indiana Agricultural Report 1885, p. 188.

[14]Loc. cit., Twelfth Report, p. 19.

[15]Loc. cit., pp. 21–22.

[16]Loc. cit., pp. 22–23.

[17]Loc. cit., Eleventh Report, p. 68.

[18]Loc. cit., Twelfth Report, p. 23.

tin, of Shabona Grove, Illinois, accuses them of eating the pulp of apples, when the skin had been broken through other causes.[19] As previously stated, there is nothing to indicate that these adults live through the winter, even in limited numbers, or that the insect hibernates in any other than the egg state. And while adults occur from June until November, no larvæ or pupæ have been observed later than the last of August.[20] Hence, while the adult insect has never been reared from the egg, on account of serious difficulties to be overcome, it is not likely that there is more than one brood during a season.

The damage done by the insect is, as previously indicated, nearly all due to larvæ, and since 1882, in localities where no preventive measures have been used, the destruction to the corn crop has been very serious. In 1885, Mr. Moses Fowler, a very extensive land owner of Lafayette, Indiana, estimated his loss, during that season, through the ravages of the pest, at $16,000, or about 15 per cent. of the entire crop. On the basis of this estimate, the loss sustained in twenty-four of the corn producing counties of that state, for that one year, would amount to nearly $2,000,000.[21] Although much more destructive on high, or tile drained lands, Prof. Forbes, in 1866, reported serious injury to a field in southern Illinois, which had been under water for three weeks during the spring.[22] There is no indication that the insect is susceptible to meteorological influences, although the effect of its ravages is aggravated by an extremely dry season. In fact, the extreme effect of the larvæ upon the plants is very similar to that of severe drouth.

There seems to be equally little aid in prospect through the influence of natural enemies. The occurrence of the larvæ of *Drasteria amabilis* as reported by Dr. Riley[23] as being found in company with the root-worm in Missouri, is very suggestive, especially as the latter are known to be of carniverous habits, but, so far, not a single instance has been recorded where the pest has been attacked in any of its stages by other insects. Prof. Forbes states that he has never found their remains in the stomachs of any of the birds whose food habits he has studied.[24]

During the entire history of the ravages of the insect in the cornfields of the United States there has not been a single instance recorded where the larvæ have injured corn planted on lands which had the previous season grown and matured a crop of wheat, rye or barley, no matter how seriously the field had previously been affected. This is largely true of grass lands also, but where the cornfields are literally overrun with the adults, many doubtless seek food and deposit their eggs in other fields. While the young larvæ may not be able to survive on the

[19]Loc. cit., p. 68.
[20]Loc. cit., p. 25.
[21]Indiana Agricultural Report 1885, p. 188.
[22]Entomologica Americana, Vol. II, p. 174.
[23]American Entomologist, Vol. III, p. 247.
[24]Eleventh Report State Entomologist of Illinois, p. 63.

roots of grass, if these are displaced, and corn planted instead, the result would be, as in the cases of some Illinois and Indiana farmers, previously cited, that the first crop would suffer to a greater or less extent. Rotating the crop with small grain has proved so effective that no trouble is now experienced by those who faithfully practice the measure.

THE BROAD STRIPED FLEA-BEETLE.

Systena tæniata (Say).

Ord. COLEOPTERA: Fam. CHRYSOMELIDÆ.

This species was first described in 1824, under the genus *Altica*[25] from the Northwest Territory, with the statement that the describer had not met with it in the Atlantic States. Variety *blanda* Mels, according to Dr. Horn, occurs from New Mexico to the Dakotas and east to New England; *ligata* Lec, is found in California and Nevada; *mitis* Lec, is abundant in California, Nevada and Arizona. Hence, as the Doctor remarks, the species is an inhabitant of the northern half of our territory from the Atlantic to the Pacific, and from Oregon and Dakota to Arizona, extending to Mexico where it has recieved several additional names.[26]

FIG. 9.

All of the varieties here given have been described as distinct species, *blanda* having been described in 1848, by Melsheimer,[27] those by LeConte later.

HABITS OF THE DIFFERENT VARIETIES.

The most common and wide spread variety, as will appear from the above, is *blanda*, which has been exceedingly abundant in Ohio the past year, and according to Prof. Smith, the same has been true of New Jersey. The beetles have been known since 1873, to destroy corn, the first notice of their depredations being recorded by Mr. Townsend Glover, the fact having been communicated to him, accompanied by specimens, by Mr. J. S. Nixon, of Chambersburg, Pennsylvania, during the month of June. It is this that gave rise to the oft-repeated statement that the species is injurious to corn in the Middle States. In 1878 or 1879, Dr. Thomas, then State entomologist of Illinois, informed the writer that this insect had

[25]Narrative of an expedition to the source of St. Peter's River, etc., under command of Stephen H. Long, U. S. T. E., Vol. II, p. 295, Philadelphia, 1824: Say's Am. Ent., Le Conte Ed. Vol. I, p. 195.

[26]Trans. Am. Ent. Socty. Vol. XVI, pp. 273-4, 1889.

[27]Proc. Acad. Nat. Sci. Phila., III, p. 164.

that season ravaged fields of young corn in Illinois. In *Spirit of the Farm* for June 16, 1883, published at Nashville, Tennessee, a correspondent complains of the destruction of his young corn by "striped fleas" which might apply to this species. In the *Prairie Farmer* of November 15, 1879, I recorded the species as feeding on the leaves of *Ambrosia*, and have since observed them in both Indiana and Ohio feeding on the leaves of young corn. Prof. Forbes has found it injurious to the foliage of the strawberry and melon, in southern Illinois,[28] while I, myself observed them working serious injury to growing potatoes in Indiana, in June 1887.[29] Dr. J. A. Lintner records their depredations on the cotton plant, he having received them from Jackson county, Georgia, in May.[30] Prof. Lawrence Bruner states that in Nebraska, they of all the flea-beetles are the most destructive to sugar beets, and gives the following additional food plants: *Amarantus*, *Chenopodium*, *Purslane*, white clover, and, sparringly on the *Cruciferæ*.[31] The beet feeding habit of the species had also been observed by myself in Indiana, in June 1890,[32] and variety *mitis* had been observed depredating on the potato, beet, bean and tomato, the beet and other *Chenopodiaceæ* suffering most, by Prof. James Cassiday, at Fort Collins, Colorado, in 1888.[33] What was in all probability variety *blanda*, was reported to the Entomologist of the U. S. Dept. Agriculture, July 26, 1890, as destructive to beans in New Mexico, by John F. Weilandy, of Santa Fe.[34]

In none of these notices, is there any reference to any stage other than that of the adult. The only notice of the early stages and development of the insect that I am able to find is that of Prof. S. A. Forbes,[35] who reared the adult from slender white larvæ feeding on kernels of sprouting corn in the earth, specimens collected May 17, pupating May 26--June 10, and adults emerging June 17. The adult is here recorded as feeding on the leaves of the common *Xanthium strumarium*. Prof. C. P. Gillette, in Bulletin 24, of the Colorado Experiment Station, states that this is one of the worst pests that Colorado gardeners have to deal with, feeding as he observes they do, not only on the plants previously mentioned, but also on alfalfa, lettuce, parsnips, egg plant and summer savory, also, on the following weeds: *Iva axillaris*, *I. xanthiifoliu*, *Salvia lanceolata*, *Verbena bracteosa*, *Solanum trifolium*, *S. rostratum*, *Helianthus annuus*, *H. petiolaris*, *Portulaca oleracea*, *Amarantus blitoides*, *Chenopodium* spp.

[28]Thirteenth Rept. Ins. Ill., 1884, p. 86: Sixteenth Rept, p. XI, 1887 and 1888.
[29]Rept. U. S. Dept. Agr., 1887, p. 151.
[30]Fourth Rept. State Ent. N. Y., p. 155.
[31]Bull. Agl. Exp. Sta. Nebr., No. 16, p. 60, 1891.
[32]Insect Life, Vol. III, p. 149.
[33]Bulletin No. 6, p. 18, January, 1889.
[34]Insect Life, Vol. III, p. 122.
[35]Entomological America, Vol. II, 174, 1886.

FOOD OF OTHER SPECIES OF SYSTENA.

The red-headed Systena, *S. frontalis*, though feeding largely on knot weed, *Polygonum*, does not hesitate to satisfy its appetite with more valuable food. Prof. William Saunders recorded it in 1882 as a depredator on the foliage of the grape [36] while I observed it in Indiana, in 1887, associated with *blanda* in the destruction of potatoes.[37] In 1889, Mr. James Fletcher complained of its depredations in the shrubbery and seed beds of the Botanic Garden of the Experimental Farm at Ottawa, Canada, the depredations being especially noticeable upon some species of *Althea*, *Hibiscus*, *Weigelia* and young grapes.[38] Prof. Lawrence Bruner found it destructive to beet leaves and also those of *Hibiscus militaris*, in Nebraska.

Systena elongata, which I also recorded as feeding on the leaves of *Ambrosia artemisiæfolia* in Illinois (Prairie Farmer Nov. 15, 1879), was observed by Mr. Wm. H. Ashmead, injuring cantaloupes and sweet potatoes, in Maryland, frequently killing the plants by skeletonizing the leaves.[39] The Margined Systena, *S. marginata*, was reported by Prof. Saunders,[40] as very abundant late in September of the previous season, on the leaves of small oaks, which were much eaten by them. The same species was stated to have been very common on elm, hickory, etc., and Mr. James Fletcher[41] reports it attacking the leaves of the service berry, *Amelanchier Canadensis*, leaving only the ribs, and giving the bushes a rusty and seared appearance.

DEPREDATIONS IN OHIO.

Late in June, it became apparent that this broad-striped depredator meant to annoy us considerably, and reports of its depredations came in from the whole length and breadth of the State. Potatoes, cabbage, beets, corn, beans—whole acres of the latter in sections where this is an important crop— were eaten to the stems or leaf stalks. As previously stated the invasion reached New Jersey, but it appeared to us as though Ohio was the "storm centre," so to speak. However, their abundance this year does not necessarily imply that they will visit us in any such numbers another year.

REMEDIES.

Mr. Fletcher found a mixture of one part Paris green mixed with twenty parts of flour and dusted on the plants thoroughly effective, and Prof. Bruner reports equally good success with kerosene emulsion.

[36] Canadian Entomologist, Vol. XVI, p. 147.
[37] Rept. U. S. Dept. Agr., 1887, p. 151.
[38] Experimental Farms Reports, 1889, p. 87.
[39] Insect Life, Vol. III, p. 55.
[40] Report Entomological Society of Ontario, 1882, p. 61.
[41] Experimental Farms Report, 1889, p. 88.

Description of the Beetle.

This is so exceedingly variable both in color and sculpture that any written description would be practically worthless to the ordinary reader, some specimens being nearly black while others are as nearly yellowish white. The accompaning figure (9), greatly enlarged, with the natural length indicated by the line at the left, will render the pest at once recognizable.

BLISTER BEETLES.

Epicauta vittata Fab.

E. pennsylvanica DeG.

E. lemniscata Fab.

E. cinerea Forst.

Macrobasis unicolor Kirby.

Ord. Coleoptera: Fam. Meloidæ.

These are the most abundant species, east of the Mississippi river, and are given in the order of their destructiveness. They are all closely allied to the Spanish fly (Cantharides of our druggists' shops), and it is claimed have some of the medical properties of their foreign congeners, though this has not yet been utilized in this country. Dr. Harris called attention to their medical properties as long ago as 1824.

Fig 10. Epicauta cinera. After Harris.

The several species indicated above may be distinguished by their various colors, though in two cases it will be observed the same species may be either ash-colored or black.

There are in this country about 175 species of these beetles, not all of which are abundant. With us there are but six species that at any time become destructive, viz.: A species that may be either ash-gray or black (*Macrobasis unicolor*, Kirby), a larger, wholly black species, (*Epicauta Pennsylvanica*, DeG.); a smaller species, usually black but sometimes ash-gray, always, however, with a red head (*E. trichrus*, Pall.); a larger species also black but with gray margins to the wing covers, more commonly known as the Margined Blister beetle (*E. cinerea*, Forst.), Fig. 10; the striped or old-fashioned potato beetle (*E. vittata*, Fab.), Fig. 11. This is yellow with four quite wide, black stripes on the wing covers. Intermixed with these in the fields is another, looking almost like the last mentioned, but having six stripes on the back instead of four. (This is *E. lemniscata* Fab.).

In Europe, the larvæ or grubs of a number of species, closely allied to those of our own country, have long been known to be parasitic on bees. The development of these insects is exceedingly interesting. Instead of four stages of development, as is the case with most insects, there are here seven, viz. the egg, first larva, second larva, coarctate or pseudo-pupa, third larva, the true pupa, and the imago. The female deposits a great number of eggs in loose, irregular masses in the ground, that hatch out small, very active larvæ, which climb up the stems of various flowering plants, and, getting among the blossoms, attach themselves to the bodies of the bees that come to these blossoms to collect the honey, and in this way are conveyed to the home of the bees, where they live and develop on the honey.

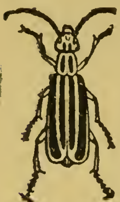
FIG 11. Epicauta vittata.

Some years ago Prof. Riley found that the species given above differed in their habits from the European species in that the larvæ instead of climbing plants, burrowed at once into the ground, where he afterwards found them in the egg masses of several species of grasshoppers, engaged in devouring the eggs, and, in fact, reared several species found feeding in this manner to the adult.

Of the striped and margined species, the two most destructive with us, he says that the eggs are laid in the loose ground, in masses of about 130, from July till the middle of October, the female excavating a hole for the purpose and afterwards covering up the eggs by scratching with her feet. She prefers to lay her eggs in the very same warm, sunny localities that are chosen by the grasshoppers for a similar purpose, and, seemingly, places her eggs in close proximity to those of the grasshoppers. In about ten days the delicate shell of the egg bursts and the young grub makes its way forth to seek its food. Though very young, and we would naturally suppose easily destroyed, yet these young appear to be able to travel about for a fortnight without food with little inconvenience. As soon as the young finds a deposit of grasshopper eggs it at once eats through the outer covering or sack, from which it often makes its first meal. Later, it attacks the egg, devouring both shell and contents. If two or more grubs find the same egg mass, there is a fight to the finish and only one remains in possession. After having eaten a couple of eggs, or in about eight days after first taking food, the larva moults and begins its second larval or grub stage, which lasts about a week, when it again casts its skin, another moult occurring six or seven days after. It is now in the pseudo or false pupal stage, which corresponds in some respects to the flaxseed stage of the Hessian fly, and in which it can remain for a long time without food, and usually passes the winter in this stage of development. In spring, this outer covering splits and another moult takes place, the grub being now in the third or final larval stage, during which it may feed if food is at hand, but if not it burrows into the ground and in the course of a few days passes into

the pupal state. This last stage is short, lasting but five or six days. Thus the entire larval period is passed in about twenty-four days, a part in fall and a part in spring, the whole time required for their development being about a month. Just how long the fully developed beetles live is not known, the fact of their occurring from June until October not necessarily implying an extended period of existence, as, in all probability, the season of emerging in spring is more or less protracted.

From an economic as well as a scientific standpoint, these insects are of very great interest. We always have an abundance of them during seasons following other seasons when there are great numbers of grasshoppers, showing that there has been an abundance of food for the larvæ, and that, owing to this abundance, myriads of the blister beetles developed. That the larvæ of those that have caused so much injury this summer will, or, in fact, are even now destroying eggs of grasshoppers, scarcely admits of a doubt. It is a good illustration of the fact that we cannot separate our friends from our foes on a single year's acquaintance. The farmer who this year has suffered from the ravages of these insects in his potato field, naturally feels a desire to see the pests exterminated; yet it is somewhat of a question if, in a series of years, he would be any better off were his desires realized. What is wanted is not the extermination of these insects, but some means of protecting certain crops from their voracious appetites, when they become overabundant.

REMEDIES.

Since we cannot prevent or restrict the breeding of these insects, even if it were desirable to do so, our only hope of relief lies in either destroying them or rendering their food distasteful to them.

Spraying with arsenical poisons, while it probably does kill many of the beetles, fails of protecting the crop. But the same may be said of almost any other known measure that has the destruction of the insect for its object, unless repeated applications are resorted to. All individuals of a species do not appear simultaneously, and some species occur earlier than others, so that applications of even so deadly a measure as fire must often be repeatedly applied.

In Spain and Italy, the cantharides of commerce are collected by being shaken from trees in early morning on to cloth spread on the ground beneath. The four corners of the cloth are then gathered up and the whole plunged into a tub of water diluted with vinegar, which kills them. I do not know of this vinegar mixture being tried on our native species and indeed its effect is somewhat doubtful. I have tried a solution of carbolic acid and water with little effect. Kerosene emulsion and whale-oil soap are too expensive for general use. In my own experiments fire has proved the most effective. Straw is placed along the edges and the beetles are easily driven across the rows and on to the

straw where they can be burned. Mr. Green, of this Station, tells me that where he applied the Bordeaux mixture the beetles appeared to abandon the potatoes and go elsewhere, and where he did not apply the mixture they did serious injury. This, then, may be just the measure we want, and it has this year been demonstrated that the application of this mixture to growing potatoes results in an increased yield, even though unaffected with either blight or insects.

It will of course require further experimentation to settle this question of the actual effect of Bordeaux, with exactness. As the matter now stands there appears a possibility of awarding off their attacks with a measure that will pay the expense of application in an increase of yield, under normal conditions. For isolated plants on the lawn and in the garden a suds of whale or fish-oil soap will be found thoroughly effective.

THE BAG OR BASKET-WORM.

Thyridopteryx ephemeræformis Haw.

(FIGS. 12, 13, 14.)

Ord. LEPIDOPTERA: Fam. BOMBYCIDÆ.

Over its area of distribution in Ohio, as also in Indiana, this insect has been exceedingly abundant the present season, and so many inquiries regarding it have come to me that a full account of its development and injuries seems desirable for the benefit of those who reside in the southern part of the State. (There is another and much smaller Bag or Basket worm that occurs in Ohio, *Psyche confederata*, but easily distinguished by its being only about half the size of this one. It was reported this season in great abundance in the vicinity of East Liverpool, Columbiana county.)

The pest is, commonly, best known in the state in which it is illustrated in Fig. 14, from a photograph from life, and the various stages of development are further portrayed in Fig. 13, while the manner of constructing of the first sack or basket by the newly hatched young is shown in Fig. 12.

EARLY HISTORY.

Dr. J. A. Lintner has so carefully looked up and recorded this in his First Annual Report of the State Entomologist of New York, that I shall copy largely from his pen, prefacing what he says only by the statement that the species was described from England in 1810.[42]

[42] Lepidoptera Britannica p. 72. 1810.

"The singular appearance of this insect, so unlike most of the Lepidoptera, was the occasion of much perplexity in its classification for a number years after its discovery. As may be seen from its synonymy, it was originally described as a *Sphinx*, although possessing none of the characteristic features of the Sphingidæ. Previous to this, it had been believed to be a species of Tinea. Later it was regarded as belonging to the Ægeridæ. An interesting paper upon the species, assigning it to its true position among the Bombycidæ, was communicated by Mr. J. F. Stephens to the Trans. Ent. Soc. Lond., I, 1836, p. 76, under the title of 'On the Apparent Identity of *Sphinx ephemeræformis* of Haworth with *Psyche plumifera* of Ochsenheimer,' of which the following is the substance:

"It appears that the original specimen was found in Yorkshire by Mr. Boton, and was placed in Mr. Drury's collection. At the sale of this collection, it was purchased by Mr. Donovan, and at an auction sale of some of Mr. Donovan's insects, in the catalogue of which it was announced as 'an undescribed *Cossus ligniperda*,' it came into Mr. Stephens' possession. Mr. Stephens was able to see, upon a cursory inspection, notwithstanding its mutilated condition, that it was not a Sphinx or even one of the Sphingidæ. He referred to 'the singular group known by the name of Sackträger by the Germans, and considered by some writers as belonging to another order of insects—*Trichoptera* Newman, *Phrygania* Scopoli, and *Tenthrido* by Roda; in fact it appears to be a *Psyche* of Ochsenheimer [*Psyche plumifera*], so far as can be ascertained by the remains of the unique specimen.' Reasons are given why it could not be classed among the Ægeridæ where it had been placed in the first volume of Illustrations of British Insects, 1834, 'nor had it any alliance with Zeuzera, to which genus it would appear Donovan had assigned it.' It did not fully agree with Psyche, and a new genus Thyridopteryx, was constituted for it."

"The above genus had been published by Stevens prior to the above paper, in Vol. IV, of his Illustrations, page 387, printed in 1835."

In our own country the early history of the species is like that of many others, involved in obscurity. According to Doubleday,[43] Mr. Gosse found the "cocoons, or rather larva-cases," plenty in Alabama in 1838. Mr. Doubleday himself found it at Charleston (State not given) as early as 1839, in abundance,[44] while Dr. Harris in 1841[45] says a case or cocoon, smaller than those found in the West Indies, had been presented him from Long Island. In the second edition of his work (1852, p. 319), he repeats this statement and says in addition that in the vicinity of Philadelphia cocoons of a similiar kind were very common, and that the inhabitants of these cocoons were called drop-worms, or basket-worms. In Harris' letter to Doubleday dated October 29, 1849, he discusses this species at length as *Oiketicus* [*coniferarum* Harr. MS.][46] and says that in Philadelphia they are called "drop-worms" and sometimes "basket-worms." In this letter Harris expresses the determination to rear the larvæ another year. That he succeeded in doing so with larvæ sent him from Philadelphia, is shown by his letter to Miss Morris dated September 25, 1850. If, as Harris supposed,[47] it was this species that

[43] Harris' Correspondence, p. 141.

[44] Loc. cit., p. 122.

[45] Insects of New England Injurious to Vegetation, 1841, p. 299.

[46] Correspondence, p. 177.

[47] Loc. cit. p. 242.

was so unskilfully figured in Smith and Abbott's work, then it was an inhabitant of Georgia nearly or quite one hundred years ago.

Geographical Distribution.

This has been pretty well outlined in a succeeding paper. It occurs from Massachusetts to Texas except Florida, and north to the vicinity of the boundary line shown in Fig. 17. In Ohio, it is found in Montgomery county and east to Washington county; if it has been found north of this I am not aware of the fact.

Habits and Life History.

On these points I quote from Dr. C. V. Riley's Bulletin 10, U. S. Department of Agriculture:

"*The Eggs.*—During winter time the dependent sacs or bags of this species may be seen hanging on the twigs of almost every kind of tree. If they happen to be on coniferous trees, and they are usually more abundant on these than on deciduous trees, they are not infrequently mistaken for the cones. In reality they are the coverings spun by our worm, and they serve not only as a protection to it, but also to the eggs. Upon cutting open the larger of these bags in winter time they will be found to contain the shell of a chrysalis (technically called the puparium), which is filled with numerous small yellow eggs (Fig. 13*e*). Each of these is a little over 1 millimeter in length, obovate in form, and surrounded by a delicate, fawn-colored, silky down. In this condition the eggs remain from fall throughout the winter and early spring.

"*The Larva and Its Bag.*—About the middle of May in the latitude of Washington the eggs hatch into small but active larvæ, which at once commence to construct a portable case or bag in which to live. The way in which this bag is prepared is curious (Fig. 12). The young larva crawls on a leaf, and gnawing little bits from the surface, fastens these together with fine silk, produces a narrow, elongate band, which is then fastened at both ends to the surface of the leaf by silk threads. Having secured itself from falling down by some threads, it now straddles this band and, bending its head downward (Fig. 12*b*), makes a dive under it, turns a complete somersault and lies on its back, held down by the band (Fig. 12*c*). By a quick turning movement the larva regains its feet, the band now

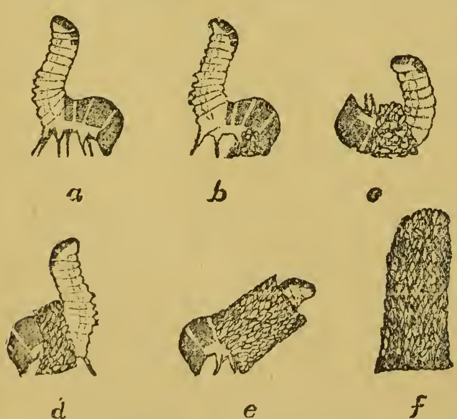

Fig. 12. Showing the way in which the young caterpillars construct their sacks. After Riley.

extending across its neck (Fig. 12*d*). It then adds to the band at each end until the two ends meet, and they are then fastened together so as to form a kind of narrow collar which encircles the neck of the worm. Far from resting, it now busies itself by adding row after row to the anterior or lower end of the collar, which thus rapidly grows in girth and is pushed further and further over the maker (Fig. 12*e*). The inside of this bag is now carefully lined with an additional layer

of silk, and the larva now marches off, carrying the bag in an upright position (Fig. 13*f* and Fig. 12*f*). When in motion or when feeding, the head and the thoracic segments protrude from the lower end of the bag, the rest of the body being bent upward and held in this position by the bag. As the worms grow they continue to increase the bags from the lower end and they gradually begin to use larger pieces of leaves, or bits of twigs or other small objects for ornamenting the outside. Thus the bags will differ according to the different kind of tree or shrub upon which the larva happens to feed; those found on coniferous trees being ornamented with the filiform pine leaves, usually arranged lengthwise of the bag, while those on the various deciduous trees are more or less densely and irregularly covered with bits of leaves interspersed with pieces of twigs. When kept in captivity the worms are very fond of using bits of cork, straw or paper, if such are offered to them. When the bags, with the growth of the larva get large and heavy, they are no longer carried, but allowed to hang down (Fig. 13*f*). The worms undergo four molts, and at each of these periods they close up the mouth of their bags to remain within until they have cast their skin and recovered from this effort. The old skin, as well as the excrement, is pushed out through a passage which is kept open by the worms at the extremity of the bag.

"The young larva is of a nearly uniform brown color, but when more full grown that portion of the body which is covered by the bag is soft, of light-brown color and reddish on the sides, while the head and thoracic joints are horny and mottled with dark-brown and white (Fig. 13*a*). The numerous hooks with which the small, fleshy prolegs on the middle and posterior part of the body are furnished, enable the worm to firmly cling to the silken lining of the bag, so that it can with difficulty be pulled out.

"The bag of the full-grown worm (Fig. 13 and Fig. 14) is elongate-oval in shape, its outlines being more or less irregular on account of the irregularities in

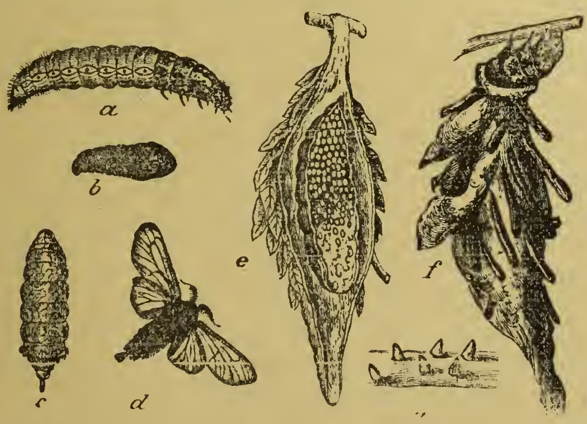

FIG. 13 The Bag or Basket Worm; *a*. full grown caterpillar; *b*. chrysalis of male; *c*, female; *d*. adult; *e*, sack containing female filled with eggs; *f*, sack or bag of full-grown caterpillar; *g*. group of very young worms in their minute sacks. After Riley.

the ornamentation above described. The silk itself is extremely tough and with difficulty pulled asunder.

"The larvæ are poor travelers during growth, and though, when in great number, they must often wander from one branch to another, they rarely leave the tree upon which they were born unless compelled to do so by hunger through the defoliation of the tree. When full-grown, however, they develop a greater activity, especially when very numerous, and, letting themselves down by a fine silken

thread, travel fast enough across sidewalks or streets and often for a considerable distance until they reach another tree, which they ascend. This migratory desire is instinctive; for should the worms remain on the same tree they would become so numerous as to necessarily perish for want of food.

"*Pupation.*—The bags of the worms which are to produce male moths attain rather more than an inch in length, while those which produce females attain nearly double this size. When ready to transform, the larva firmly secures the anterior end of the bags to a twig or branch, and instinct leads it to reject for this purpose any deciduous leaf or leaf-stem with which it would be blown down by the winds. The inside of the bag is then strengthened with an additional lining of silk, and the change to chrysalis is made with their heads always downward. The chrysalis is of a dark-brown color, that of the male (Fig. 13*b*) being only one-half the size of that of the female (Fig. 13*c*).

"*The Imago or perfect Insect.*—After a lapse of about three weeks from pupation a still greater difference between the two sexes becomes apparent. The male chrysalis works its way to the lower end of the bag and half way out of the opening at the extremity. Then its skin bursts and the imago appears as a winged moth with a black, hairy body and glassy wings (Fig. 13*d*). It is swift of flight, and, owing to its small size and transparent wings, is rarely observed in nature. The life-duration of this sex is also very short. The female imago is naked (save a ring of pubescence near the end of the body of yellowish-white color), and entirely destitute of legs and wings (Fig. 13*e*). She pushes her way partly out of the chrysalis, her head reaching to the lower end of the bag, where, without leaving the same, she awaits the approach of the male. Fertilization being accomplished, the female works her way back within the chrysalis skin and fills it with eggs, receding as she does so toward the lower end of the bag, where, having completed the work of oviposition, she forces, with a last effort, her shrunken body out of the opening, drops exhausted to the ground and perishes. When the female has withdrawn the slit at the head of the puparium and the elastic opening of the bag close again, and the eggs thus remain securely protected until they are ready to hatch the ensuing spring."

FOOD PLANTS.

Of these Dr. Lintner gives the following list:

"The caterpillar is a very general feeder, readily feeding on a large number of our fruit, forest and other trees. It has been observed on apple, pear, plum, cherry-choke-cherry, apricot, quince, linden, maple, locust, oak, elm, poplar, osage orange, spruce, hemlock, larch, red cedar and arbor vitæ. For the last two, it seems to manifest a decided preference."

While of the trees not affected, Dr. Riley has the following to say:

"The hard maples are, as a rule, avoided by the worms, and it is also quite noticable that they are not particularly fond of oak leaves and those of the Paulouais. The Ailanthus trees are also generally exempt from their attacks, either on account of the unpleasant taste of the leaves, or perhaps on account of the compound nature of the leaves, the worms fastening their bags to the leaf stems which fall to the ground in fall. The China trees of our southern cities are entirely exempt from the worms. With these exceptions, the worms, when sufficiently numerous, do great damage to most other kinds of trees used in our cities as shade and park trees."

"The Bag-worm is so well protected in all its stages that no insectivorous bird nor predaceous insect is known to attack it. In spite of the absence of predaceous enemies, the Bag-worm suffers from the attacks of at least six true parasites, while

two others, which may be primary but are probably secondary, are reared from the bags. Three of these are Ichneumonids, viz.: (1) *Pimpla conquisitor* Say; (2) *Pimpla inquisitor* Say, and *Hemiteles thyridopterigis* Riley. Of these, the last named is most abundantly bred, and we have always considered it as the most important parasite of the Bag-worm. The past season, however, we have ascertained that three species of the genus Hemiteles, viz.: *H. utilis*, and two undescribed species, are unquestionably secondary parasites, and this renders it quite likely that *H. thyridopterigis* may also be secondary, or, in other words, a parasite of one of the true parasites of the Bag-worm. It is a question, however, which only the most careful study, with abundant material, can decide, as the law of unity of habit in the same genus finds many exceptions in insect life. The other parasites are as follows: (4) *Chalcis ovata* Say. This parasite is a very general feeder on Lepidopterous larvæ, and we have bred in from seven widely different species. (5) *Spilochalcis mariæ* (Riley). This species, while parisitic on Thyridopteryx, is more partial to the large silk-spinning caterpillars, as we have reared it from the cocoons of all of our large native silk-worms. (6) *Pteromalus* sp. This undescribed Chalcid is found very abundantly in the Bags, but may be a secondary parasite. (7) *Dinocarsis thyridopterygis* Ashmead. This parasite was bred from the Bags in Florida by Mr. William H. Ashmead, who believes it to be parasitic on the eggs. (8) *Tachina* sp. We have bred a large bluish Tachinid from the Bags. Its eggs are commonly attached to the Bags externally, near the neck, and the young larvæ, on hatching, work their way into the case. They frequently fail, however, to reach the Bag-worm."

At North Bend, near Cincinnati, I found larvæ that had been paratized by a Tachinid, but did not succeed in rearing the adult. The pres-

FIG. 14. Bags of full grown caterpillars of *Thyridopteryx ephemeræformis*, attached to a twig of cedar. From photograph from nature, by F. J. Falkenbach, of Ohio Experiment Station.

ence of the parasite could be determined by the pupa protruding from the lower extremity of the sack and strongly resembling the anterior portion of the chrysalis of the male.

In regard to Prof. Riley's statement with respect to the attacks of birds, while I have no direct proof to the contrary, there is a strong suspicion, however, that the species has one or more enemies among the feathered tribes. Some years ago I received, from Prof. Curtis, of Texas, a number of these larvæ in their baskets, and being alive and active when received, they were placed on a tree in my yard. They with one exception soon fastened their baskets permanently to a twig, in a cluster, the exception, after rambling about for a day or so, located at a distance from the others and on a twig that was well sheltered from the wind by an angle of the house. I watched them for a considerable time and they were plainly located for good. Some weeks later, on going to the tree to secure them, intending to take them indoors for further observation, I was unable to find the isolated individual anywhere, either on the ground or on the tree. Knowing that it had been securely anchored and could not have been torn loose by the wind, it was a puzzle to me as to how it became detached.

The present summer, Mr. Davis L. James, of Cincinnati, stated to me in conversation that he had recently observed sparrows engaged in pecking at some of these baskets that had, in some unaccountable manner been detached from the limbs of a box elder and were lying on the ground. Now, all of this proves nothing in regard to the birds, but, it seems to me to be a point well worth following out by observation, in localities where both the insect and sparrows abound, and is, therefore, given here to be accepted for what it is worth. The English sparrow is known to attack the Periodical Cicada, and threatens to exterminate some of the weaker broods, especially where the latter are already much reduced in numbers, and I have repeatedly observed these birds pecking the *Lachnosterna* or May Beetles that had fallen beneath electric lights during the night. In the case of the Cicadas, the first move of the bird, after capturing its prey, was to adroitly clip off its wings, after which it would leisurely extract and devour the contents of the abdomen, rejecting the balance.

In his admirable little book, "Tenants of an Old Farm," pp. 52–54, Rev. Henry C. McCook, records the fact of these sparrows pecking at the cocoons of *Samia cynthia*, but says that he does not know, from actual observation, that the birds wished to tear open the cocoons for the sake of the contents, and thinks that in early spring their motive might be to secure material for their nests. It will be noticed, however, that the observations of both Mr. James and myself were made in late summer or autumn.

Remedies.

Collecting and burning the bags or baskets, during the fall or winter, will prevent their appearance another season. This is somewhat laborious, and a spraying of infested trees with arsenical poisons, as for the codlin moth will be found thoroughly effective. A pound of Paris green and twenty pounds of lime, mixed with two hundred gallons of water, will make short work of these caterpillars, if applied late in June or even early in July, and if faithfully done, no other measure will be necessary.

THE CABBAGE APHIS.

Aphis brassicæ Linn.

Ord. Hemipera: Fam. Aphidiæ.

This is another imported insect, coming to us from Europe, and whence it has become diffused over many countries, being found in Australia and other distant localities. It has been known in this country since 1791, and was described in 1767.

It is quite probable that the life history of this insect is much like that of *Aphis mali*, as we are fast learning that the old idea of these Aphides having but a single food plant is fallacious. There are good reasons for believing that the Cabbage Aphis migrates in the fall, largely at least, to some plant on which it oviposits, and on which the first generations develop in the spring, and from which they migrate to the cabbage. The Apple-tree plant louse, noticed elsewhere, and the Hop Aphis, which originates in spring on the plum, are sufficient illustrations, but they apply to the northern portions of the country only.

Before going farther it will be necessary to explain something of the methods of reproduction among Aphides. There are two; (1) by giving birth to their young, after the manner of animals, and (2) by depositing eggs. Eggs are deposited in the fall only, and it is only at this time that there are both males and females. The eggs hatch in spring and produce females exclusively, and continue in this way until fall. The egg-laying females and the females originating from the eggs are wingless and the latter are termed stem-mothers. While this is true in the main, yet it is equally true that as we go southward, and the cold season is shorter and milder, there is less oviposition and the viviparous females remain on the summer food plant during the winter. In southern Texas I found this species very abundant in February on old cabbage that had wintered in the fields. I might also add that these very peculiar methods of reproduction are not of recent origin nor are these insects in the act of changing their habits in this respect. Geological investigations show us that at least as long ago as the Miocene period these insects had practically the same metamorphosis that they have at present. In fact we

find that the genus *Pemphagus* then, as now, was a gall-maker on various species of cottonwood. Besides this these insects are found in the fossil resins of northern Europe.

My predecessor found eggs of the Cabbage Aphis on cabbage late in the fall, and from the fact reasoned that the destruction of these eggs would result in a reduction of the pest another year. After having studied the matter very carefully and reasoning from the same premises I can only arrive at precisely the opposite conclusions. While I do not in the least doubt that eggs are frequently deposited on the cabbage in the fall, I feel very sure that it is only the delayed females, which really constitute only a reserve force as it were, that oviposit thus, while the majority of ovipositing females have originated on some other plant, from adults that had left the cabbage at an earlier date. It certainly requires no great effort to see that lice emerging from eggs on a perfectly dead plant will be very apt to perish, and, indeed, the loss of these does not affect the continuity of the species. So, then, by destroying the cabbage in the fall we would only precipitate an event that would naturally come about later. But the matter does not end here. There are many insect parasites that do winter over on the leaves, and with the coming of spring, emerge and seek out the Cabbage Aphis, probably destroying more or less of them. By destroying the old cabbage these will also be destroyed, when if unmolested they would seek out hosts and go on with their work of destroying the pest. In other words, we would have sacrificed a large number of natural enemies for the sake of destroying a few eggs, when the young hatching from them, if left to themselves, would have perished through natural causes. In the northern states the only precaution necessary is to see that no young cabbage sprouts are sent out by the old the following spring, which can be prevented by simply pulling them up in the fall, letting them lie on the ground. In the far south, where the conditions are different, Dr. Weed's suggestions might be more appropriate, though this statement must not be construed to mean that there are no egg-laying females in the warmer portions of the country.

Remedies.

While a number of measures have been tried with a view of killing the lice on the young plants none have given satisfactory results, except kerosene emulsion and tobacco dust. The emulsion will be found much more effective if made with whale-oil soap. I have tried to destroy the pests by evaporating bi-sulphide of carbon among the infested plants covered with a heavy canvas, but the result only proved a failure.

Below are given the formulas for making kerosene emulsion and also one for making fish-oil soap; the last as given by Prof. Smith, of the New Jersey Experiment Station:

For standard emulsion:

Kerosene	2 gallons.
Water	1 gallon.
Soap	half pound.

Make a suds of the soap and water, and pour boiling hot into the kerosene. Churn with a force pump for ten minutes, until it forms a thick cream. Dilute with 12 to 15 parts of water when cold.

By the Cook formula this is made as follows:

Kerosene	1 gallon.
Water	4 gallons.
Soap	quarter pound.

Churn as in the preceding and dilute with 4 to 6 parts water when cold.

The fish-oil soap may be bought for about twelve cents per pound, or can be made much more cheaply as follows:

Hirsh's crystal potash lye	1 pound.
Fish oil	3 pints.
Soft water	3 gallons.

Dissolve the lye in the water, and when brought to a boil add the oil. It should boil about two hours, and when done can be filled up to make up the loss by evaporation.

"It is effective at the rate of one pound to eight gallons of water.'

Natural Enemies.

As with the apple-tree louse, this species has numerous insect enemies which prey upon it, reducing it in numbers greatly. Dr. Riley has reared an Ichneumon, *Trioxys piceus* Cresson, from the lice.[48] I have reared *Allotria brassicæ* Ashmead and *Lysiphlebus raphæ* Curtis from these lice infesting Scotch kale, at La Fayette, Indiana, and also from the same host on cabbage in Ohio. From these lice infesting mustard, at Columbus, Ohio, I reared *Diplosis aphidiphagus* Webster MS., and also here at Wooster from lice on cabbage. Of the Coccinellidæ, *Megilla maculata*, *Hippodamia glacialis* and *Coccinella 9-notata*, have in my observation, been the most efficient in destroying these lice. Of the Syrphus flies and Lace wings, there are a number of species of each, that aid materially in holding the pest in check.

THE APPLE PLANT-LOUSE.

Aphis mali Fabr.

(Fig. 16.)

Ord. Hemiptera: Fam. Aphididæ.

This is the little green louse that is so abundant on both leaf and fruit buds of the apple, appearing usually just as these are expanding, in early spring. These insects are especially noticeable when the season is

[48]Rep. Comm. Agr., 1884, p. 318.

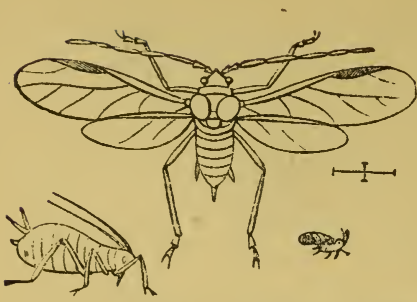

FIG. 16. Aphis mali; winged adult: at the left, young enlarged; at the right, adult about natural size. After Fitch.

cold and backward, as has been the case for the last two years. If any injury is done by them in the orchard, it is during such seasons, as, under favorable conditions for plant growth the buds unfold too rapidly to be checked by any influence these lice are likely to have on them. By the third week from the time the eggs begin to hatch, these lice begin to acquire wings and then abandon the trees and go to the grasses and probably some of the common weeds.

The species was described many years ago, and was long since introduced into this country. I give here the statements of Dr. Asa Fitch-which, with some exceptions, notably the time required for development from the egg to the adult, will I believe be found correct.[49]

"In many instances it is extremely difficult to determine whether the lice upon our American trees and plants are identical with those which occur upon the same or similar vegetation in Europe, the descriptions given by them by the old authors being so very brief, and often drawn up from a superficial examination of the species. And I have heretofore been in much doubt whether this common Aphis of our apple trees was the same insect which similarly infests the orchards of Europe, named *Aphis Mali* by Fabricius; that species being described by him, by Kollar and others, as being of a green color, whereas, our insect in its winged state is almost invariably black, its abdomen only being green. But having recently been favored with specimens of the European insect, from my esteemed friend Dr. Signoret, of Paris, and also on comparing our Aphis with the description given of the European by M. Amyot (Annals Entom. Soc., France, 2d series, vol. v, page 478), and the detailed account of the veins of its wings, furnished by Mr. Walker (List of British Museum, page 985), not the slightest doubt remains in my mind, but that the insects of the two continents are identical, and that upon this side of the Atlantic it has been introduced by the trees brought hither from Europe.

"The history of this species and its annual career is as follows: Early in the spring, sunk deep in the cracks and crevices and in the bark of the apple trees, may be seen numbers of small, oval, black, shining eggs, from which these insects are produced. Scraping off the dead bark of old trees, and coating the trunks of all the trees with whitewash at that period of the year is a practice of much utility, since thereby most of the eggs and some other insect depredators will be destroyed and the health of the tree promoted. These eggs hatch quite early, as soon as the buds begin to expand, and the young lice locate themselves upon the small, tender leaves, inserting their beaks therein and pumping out their juices. All of the lice thus hatched are females, and reach maturity in ten or twelve days. Without any intercourse of the sexes, these females that are produced from eggs, now commence giving birth to living young, bringing forth about two daily, for a period of two or three weeks, when having become decrepid with age, they perish. The young mostly locate immediately around the parent, as closely as they can stow themselves. Upon a young leaf, in a space less than half an inch long and the tenth of an inch

[49] First and Second Reports on the Noxious and Beneficial Insects of N. Y., by Dr. Asa Fitch, pp. 50-2, 1855.

wide, I counted thirty-six young lice and four winged females, which had recently alighted there to begin a new colony. The young reaching maturity after a similar length of time in their turn become parents. Thus these vermin continue to breed, and as fast as new leaves expand they are in readiness to occupy them. When favorable circumstances attend them, their multiplication surpasses all power of computation. In the warmth of summer they attain maturity in less than half the time they do early in the spring. And like most of the species of the Aphides they at this period of the year produce winged as well as wingless females, the former dispersing themselves to found new colonies upon other trees. It is reported of the insects of this family, that there are from sixteen to twenty generations in the course of the season, from twenty to forty young being produced from each parent. Thus, from one egg, as stated by Mr. Curtis, in seven generations, 729 millions of lice will be bred. And if they all lived their allotted length of time, by autumn everything on the surface of the earth would be covered with them. When cold weather begins to approach, males as well as females are produced, and their operations for the season close with a deposit of a stock of eggs for continuing their species another year. On the last day of last October, it being a warm sunny day after many nights of frost, I observed myriads of winged and apterous lice wandering about upon the trunks, the limbs and fading leaves of all my apple trees, many of them occupied in laying their eggs. These were scattered along in every crevice of the bark, in many places piled up and filling the cracks, and others were irregularly dropped among the lichens and moss growing upon the bark—every unevenness of the surface, or wherever a roughness afforded a support for them, being stocked with as many as could be made to cling to it. The eggs were then of a light yellow or green color, and were so slightly glued in their places that it was evident by far the largest part of them would be washed away by rains or brushed off by the driving snows of winter. But I by no means anticipated such a great dimunition in their numbers as actually occurred. I should judge that in the spring several hundreds had disappeared for every one that then remained."

Of the three principal species of Aphides infesting our smaller cereals, this species occupies an anomalous and at the same time important position. In point of numbers it is very greatly in advance of *Toxoptera graminum*, and, usually, of *Siphonophora avenæ*, and its effects on young wheat during the fall is, if anything more serious than either of the others, especially if the land be poor and the weather be dry. So far as my own observations go, it is more detrimental to the wheat than to the apple. The occurrence of the eggs on the twigs of apple, during winter, and the appearance of the young on the first tender buds and leaves in the spring, are familiar to all horticulturists. I have several times made the attempt to colonize the species on wheat plants, with individuals taken from the apple, but was never able to thoroughly succeed in this until this year, when a series of experiments was begun in the insectary which swept away any previous doubts on the subject of migrations.

Several years ago, on April 17th, all stages of *A. mali* were found on the young buds of quince—a new food plant so far as published record goes—and being unrecognizable without the winged adults, the attempt was made to carry them on artificially until these would appear. In doing this a number escaped from the breeding cage where they were kept, and

took up their abode on some young wheat, growing in a box on the same table. Not knowing with what generation I began investigating it on the quince, it is of course impossible to say whether, as with the Hop Aphis, it is not until the third brood is reached that adults attempt to escape to other plants, and if it was to this third brood to which the escaped individuals belonged. It will be only safe to say that they were winged and migrated. A wingless female from the quince also strayed from the cage and stationed herself on some of these wheat plants, and produced a number of young, but these all died and fell from the plants. At the same time, in a large cage out of doors, others of this species were being reared from the eggs on twigs of apple. Wheat was sown within this cage, and some of the winged adults, after leaving the young buds and leaves, went first to the muslin sides of the cage and afterwards to the wheat plants. One of these remained for two weeks alive, on one of the plants, but I could not see that she produced young. While these transitions were certainly made between the tree and grain plants, nature apparently chose to accomplish it only by her own methods, and would brook no interference or human assistance.

Early in March of the present year (1893) I placed in the insectary a couple of small seedling apple trees and to these bound twigs from the orchard, thickly stuck with eggs of this *Aphis mali*. In the same bench, about twenty feet away, wheat was sown, while some corn was planted in the intervening space. A pot containing a strawberry plant infested by another species of Aphis, and which were attended by ants, *Lasius flavus*, had previously been placed on this bench. With the hatching of the *mali* a large portion of the ants abandoned their wards on the strawberry and gave their attention to the new ones on the apple. The strawberry was then removed, but they still clung to their new found friends. As the population on the apple increased the ants distributed the apterous females to plants of Poa, Setaria, and *Ambrosia artemisiæfolia*, but especially to the wheat, carrying them by the corn to the wheat beyond, which soon became overrun with aphis. Later, they began to colonize their wards on the corn, but this seemed to be less desirable than either the wheat or grass. Winged *mali* left the apple unaided, and after taking up their position on the wheat began their labor of reproduction. On this wheat being uprooted the indefatigable ants removed them to a few wheat plants still farther away from the apple.

The species also lives over winter in the wheat fields, at least during mild winters, and I have found females reproducing every month of the year. Here, in the west, when the young wheat comes up in September and October, the winged females appear on the plants and give birth to their young, and these crawling downward attach themselves to the stems just below the surface of the ground, or often on the roots themselves. Here they go on reproducing when the temperature is favorable, the adults being apterous, so far as observed by me, until spring,

when they ascend to the foliage, the adults being after this both winged and wingless. On the stems and roots below the surface of the ground, they are of a greenish color tinged with reddish brown, especially posteriorly, the full grown individuals often being wholly of a dark brown. It is during autumn that they do their greatest injury to wheat by sucking the juices from the young plants, often, if on poor land and during dry weather, checking their growth and causing the foliage to turn yellow.

My previous experiments in rearing the species were in some respects unfortunate, in being interrupted, although there was some profit attached to the failures. The results, as well as the whole series of experiments, as they were carried out, are here given.

Infested wheat plants were taken from the field and placed in breeding cages, out of doors, April 5th. May 6th, from what appeared to be the second generation from the individuals from the fields, two pupae were selected and isolated on wheat plants. On the 8th both began reproducing, but only one of them was retained, the other being destroyed. The retained female produced five young between 7:30 A. M. and 5:30 P. M. of the 8th, and eleven more up to 7:30 of the 9th. Six young were found on the morning of the 10th, five on the morning of the 11th, three on the morning of the 12th and three on the morning of the 13th, but the mother was nowhere to be found, she evidently having escaped from under the glass with which the plant was covered. Her progeny of the 8th, five in number, had been kept on a separate plant under another cover, and these, except one which was killed by accident, reached the adult stage on the 15th. Two of these were winged and two were wingless, and one of each produced young as follows:

May	15, winged female had produced		0	and wingless	8	young.
"	16,	"	0	"	11	"
"	17,	"	7	"	7	"
"	18,	"	3	"	8	"
"	19,	"	2	"	7	"
"	20,	"	3	"	5	"
"	21,	"	2	"	10	"
"	22,	"	3	"	9	"
"	23,	"	1	"	1	"
"	24,	"	3			
"	25,	"	0			
"	26,	"	0			

The winged female died on the 26th, after producing 24 young in twelve days. The wingless female escaped on the 23rd, after producing 65 young in nine days.

Females were again secured and produced young on June 2nd, after which the parent was destroyed, the progeny themselves giving birth to young on the 8th. A wingless female was selected and reproduced as follows:

June 8, produced 7 young.		June 18, produced 1 young.	
" 9,	" 3 "	" 19,	" 1 "
" 10,	" 3 "	" 20,	" 1 "
" 11,	" 6 "	" 21,	" 2 "
" 12,	" 6 "	" 22,	" 4 "
" 13,	" 5 "	" 23,	" 1 "
" 14,	" 4 "	" 24,	" 1 "
" 15,	" 5 "	" 25,	" 1 "
" 16,	" 3 "	" 26,	" 1 "
" 17,	" 4 "		

The female continued to live a few days longer but died without further issue, she having produced 59 young in nineteen days.

The results of the rearing of this species show that, as with the others, the winged female is the least prolific. It is also probable that some individuals are more productive of young than others, and that the species as a whole may be more prolific early in the season than later on towards midsummer.

As a comparison of the rapidity with which the species multiplies I append the following record of similar experiments with the grain aphis, *Siphonophora avenæ:*

A female was isolated on a wheat plant May 5th, and on the next day, having in the meantime given birth to four young, she was destroyed. On the 14th two of these were also destroyed, the remainder reaching maturity, one being winged and the other apterous. These were both kept on plants under glass, and carefully watched, with the following results, the young being destroyed as fast as produced:

May 15,	winged female	had produced	1	and wingless	6	young.
" 16,	"	"	3	"	4	"
" 17,	"	"	4	"	4	"
" 18,	"	"	5	"	6	"
" 19,	"	"	4	"	8	"
" 20,	"	"	2	"	5	"
" 21,	"	"	4	"	7	"
" 22,	"	"	3	"	4	"
" 23,	"	"	1	"	6	"
" 24,	"	"	1	"	4	"
" 25,	"	"	2	"	3	"
" 26,	"	"	1	"	3	"
" 27,	"	"	2	"	6	"
" 28,	"	"	0	"	2	"
" 29,	"	"	2	"	3	"
" 30,	"	"	3	"	8	"
" 31,	"	"	1	"	2	"
June 1,	"	"	0	"	2	"
" 2,	"	"	0	"	0	"
" 3,	"	"	1	"	1	"
" 4,	"	"	0	"	3	"
" 5,	"	"	0	"	2	"

The wingless female died on the 6th, but the winged female lived on, without issue, until the 11th of June. The period of reproduction being 19 days with the winged female and 21 days with the wingless, the former producing 40 and the latter 89 young.

I found that the young moulted on the second, and began reproducing either late on the seventh or early on the eighth day after birth. The insects and plants were inspected, and the young removed each morning, usually about eight o'clock, so that the young were the reproduction of the preceding 24 hours.

Remedies.

There is some uncertainty in regard to the efficiency of kerosene emulsion in destroying the eggs of this pest, on the apple trees, without also injuring the tree itself. It seems quite probable that comparatively few of the eggs hatch, and, if taken in time, the young can be killed on the buds and very young leaves by the use of this insecticide. It is, however, doubtful if this would materially affect the numbers on the wheat several months later. I know of no way of reaching them in the wheat fields with topical applications. A rich soil, with that management that will best facilitate a vigorous growth of the young wheat plants, will come as near solving the problem of protection against the effect of these insects as anything now known.

Natural Enemies.

This pest has its full share of these. Some rather indefinite observations of mine lead me to suspect that at least two very minute insects destroy the eggs. These are *Gonotocerus brunneus* Ashmead, MS. and *Cosmocema citripes*. From the lice themselves I have reared similar but larger parasites as follows: *Pachyneuron micans* Howard, and *Lysiphlebus tritici* Ashmead, the former attacking its host while on grass and the latter while on young wheat, and there are probably others.

Lady beetles destroy these lice in great numbers, as also do the larvæ of Lace-wing flies. In many cases when the lice are swarming on the trees, small flat worms or maggots appear among them. These maggots are blunt at one extremity and pointed at the other, of a greenish white color with brown backs. They move about among the lice, feeding on such as they can reach, and finally transform to pretty yellow and brown flies, known as Syrphus flies.

SOME INSECT IMMIGRANTS IN OHIO.

In the following paper the term immigrant is to be understood as given in our lexicons, viz: a species that has come to this State from elsewhere and taken up its permanent abode in our midst, and is not migratory in the sense that that term is used when applied to migratory birds, whose movements are, to a large degree, influenced by the seasons. While the insects mentioned in the following account are largely of transatlantic origin, yet this is not true in all cases, and the term foreign is hereafter intended to apply to territory outside of the State of Ohio. Nor do I intend to enumerate all of the foreign species that have gained a residence within the boundaries of the State, but to give some facts relative to the time, place and method of introduction of a number of them.

Not every farmer or horticulturist is aware of the influence of rapid transportation facilities and close commercial relations on the diffusion of insect pests, not only between states, but nations as well. And the economic entomologist, who, twenty-five years ago, could work very satisfactorily within the boundaries of a very limited territory must now keep in touch not only with his immediate neighbors, but must know also what is transpiring in other countries, not knowing what year some foreign species may appear along our shores. At the present time it is not long after an undesirable immigrant of this sort gains a footing in this country before it is discovered, and its evil habits while at home are published far and wide and its progress inland heralded in advance of its coming. This is especially true with respect to the injurious or beneficial, from the fact of their being more closely watched and their movements better understood; but among the earlier known species we find that even these are often difficult to follow in their advance across the country. There are, seemingly, two of what we may term gateways through which the majority of species that have come to us from the east have made entrance into the State, and, later, spread out over the northwest. The first, and apparently the most important one of these, being at the extreme northeastern part, adjoining Lake Erie and which we might term the north gate, and, second, the valley of the Ohio river, from a point where it begins to form the eastern boundary of the State, southward—perhaps to Wheeling, W. Va. Now, there also appear to be two great national avenues or highways which insect migrations follow; progressing more rapidly along either one or the other, but not equally so along both, and often following only one; the more sub-tropical species, whether American or introduced, taking the southern or what I would call the Great Southwestern route, while the sub-arctic, including, besides American, such species as have come to us from England or Europe north of latitude 45° north, take what I would term the Great Northwestern route. There are, however, occasionally some very striking exceptions to this rule, as pointed out by Mr. E. A. Schwarz, in a paper read before the Entomological Society, of Washington, a year or

two ago. In this paper (Proc. Ent. Soc. Wash., vol. 1, pp. 182-94) several examples are given, among which is our common willow beetle (*Lina lapponica*), which in the Old World occurs only in the north and on high mountain ranges, whereas in North America it extends to the extreme southern portion of the country. A carrion beetle (*Silpha lapponica*) occurs all over North America, except the southeast, and is common as far south as San Diego, California, while in Europe it is strictly arctic, and does not occur even in the alpine regions. Notwithstanding these exceptions, however, the rule is as stated above, and the dividing line between these two great thoroughfares may be indicated approximately, as shown in Fig. 17, by a line drawn from New York City, latitude 40° 43′ north, to St. Louis, Missouri, latitude 38° 38′ north, thence to Pueblo, Colorado, latitude 38° 17′ north (about), the line of separation trending northward, east of St. Louis, under the influence of the gulf stream and the great lakes, chiefly the former. Of course it is not to be understood that this line is direct, as it is doubtless more or less irregular, and from its very nature, to some extent unstable, nor is it to be supposed to form a radical boundary, as some northern forms gradually work their way south of it, and *vice versa*. Yet it will, I think, be found approximately correct.

One of the first species to push its way across our country was the Angoumoise Grain Moth, *Gelechia cerealella* Oliver. From the best information we can obtain, it seems to have been introduced into this country from southern France, as early as 1728, occurring at that time in

FIG. 17. Indicating, approximately, the natural divide between the northern and southern insect faunas east of the Rocky Mountains.

North Carolina. This is a southern species, and it is no way likely that it entered from the north, but found its way into Ohio, where it appeared, probably about 1840, from Kentucky. It has not, so far as I am aware, been observed in any considerable numbers north of the line indicated, but has pushed its way to the southern part of Texas. The wheat midge, *Diplosis tritici* Kirby, which probably came to us from England, via Quebec, Canada, entered the United States through northern Vermont in 1828–29, pushing southward and westward, but seemingly making more rapid progress to the west. This certainly entered Ohio through the northern gateway, over-running the State, as also Indiana. Though reported, first in 1843, and again in 1847, in central Ohio, it was in 1849 reported in destructive numbers along the northern part of the State, while the eastern and southern portions seemed exempt. Therefore, I conclude that it came to the State through the north gate. It is one of the species that has followed both the northwestern and southwestern routes, but has probably made more rapid progress and advanced further along the former. Of the early movements of the Hessian Fly, *Cecidomyia destructor* Say, in Ohio, I have no exact data. It might have come up from the South, or entered by either of the two eastern gateways. Like the wheat midge, however, it appears to have made more rapid progress north of the line than south of it. The Imported Cabbage butterfly, *Pieris rapæ* Linn., a native of England, but first appearing in this country in the vicinity of Quebec, Canada, in 1860, pushed its way southward, and in ten years had reached southern New York. From here it gradually moved to the west and south, being first observed in Ohio, about Cleveland, in 1873, a year earlier than elsewhere in the State. From this we infer another entrance through the north gate. Though spreading southward, so that the line given does not at present mark the boundaries of its habitat, yet it flourishes best near or to the north of it, and is not nearly so abundant in the Gulf States, though reintroduced into South Carolina in 1873 and in Florida in 1874. It has mainly followed the northwestern route, but, like the wheat midge, its southern boundary lies far south of the line. The three clover insects, *Cecidomyia leguminicola* Lint., *Hylesinus trifolii* Muel., *Phytonomus punctatus* Fab., without exception, I believe, first came to us from the northeast; though the last two are now known to occur in extreme southwestern Ohio and southeastern Indiana. They probably entered the State from the southeast by way of the Ohio river, at a later date, there being no continuation of the northern colonies to the southward so far as I have been able to observe or learn. *P. punctatus*, which was found about Cincinnati by Mr. Charles Dury, in 1892, was very likely carried down the Ohio river, having been washed into some of its upper tributaries, one of which, Beaver river, takes its rise in northeastern Ohio, by the very high waters of the last two years, and deposited by the receding waters along the banks. There is, however, another element that promises to figure in the diffusion of

this species, and that is the wind. Mr. Ottomar Reinecke, of Buffalo, N. Y., writes me that the insect is especially abundant there just after a heavy east wind has been blowing. This phenomenon was also observed by Mr. A. H. Killman, Ridgeway, Ontario, in 1884. It would also seem that a lack of clover will not prove a barrier to its progress, as I find it even shows a preference for white clover over the red, and besides, have taken the beetles under circumstances that strongly indicate that they feed on the leaves of burdock, while Mr. J. S. Hine has sent me specimens from near Toledo that he found feeding in numbers on the bloom of solidago, with which I found their stomachs literally packed. What the final distribution of this species in this country will be no one can foresee, as in Europe it is found from Sweden south to Italy, where it was known to depredate on clover as long ago as 1867, with a probability that similar injuries were caused as early as 1834.

Hylesinus may have been introduced into southwestern Ohio in the same manner as the Clover-leaf Weevil, but at an earlier date, as it has already become abundant enough to prove destructive in the counties of Dearborn and Franklin in Indiana. It has come to us from Southern Europe and will likely gradually spread over the country, first directly west and then gradually southward. The Grave-yard beetle, *Otiorhynchus ovatus* Linn., another insect that has come to us from the Old World, its native country being Arctic Siberia on the Jenisei, and the southern portion of western Siberia, breeds freely here in Ohio among the roots of bluegrass, and is known to injure the roots of the strawberry, while the adults not infrequently enter houses in great numbers. At present it has swept across Ohio and Indiana, and is on its way through Illinois. I do not know how far it extends to the southward. The Asparagus Beetle, *Crioceris asparagi* Linn., whose native home is Europe and Siberia, was introduced into Long Island, N. Y., about 1859, and reached Ohio probably about six or seven years ago, being first observed in Columbiana county to which it doubtless came via the Ohio river. It is also found in Cleveland, and has formerly occurred about Chicago, Illinois, where it may have been introduced by infested stalks, shipped into those cities for consumption in spring, from the east. Its congener the 12-spotted Asparagus Beetle, *C. 12 punctatus* Linn., which also inhabits Europe and Western Siberia, was first observed about Baltimore, Md., by Prof. O. Lugger in 1881, is likewise spreading out to the westward, but also moves very slowly.

The Horn Fly, *Hæmatobia serrata* Rob-Desv., probably came first from the northeast, followed almost immediately by an independent introduction by way of the southeast gateway. Coming originally from France, this species, in spreading over our country, does so entirely regardless of the lines we have drawn. Still, its more rapid progress along the southern route, where the facilities for its diffusion are much inferior to those along the northern route shows that it is swayed by the same in-

fluence that have directed the course of other species. So far, we have been dealing largely with species of trans-Atlantic origin. Now we will take an American species—the Locust Borer, *Cyllene robinæ* Forst. This species has for upwards of a century been known in New York, as an enemy of the Black Locust, *Robinia pseudacacia* L. Some time about the year 1850 it began its invasion westward across northern Ohio, Indiana and Illinois, reaching the Mississippi river about 1865, carrying death and destruction to the Black Locust along its path, but not at once extending its ravages, to a serious degree, in the southern portion of these States. Again, reversing the order of migration that we have been following, we will take another American species, *Doryphora* 10-*lineata* Say. Starting in Colorado, it pushed its way rapidly eastward to the Atlantic coast, and, though not confined to our northwestern route, as we have termed it, nevertheless, its most rapid progress and greatest destruction was executed north of our imaginary line. Even yet it has not spread southward to the Gulf of Mexico.

Another species of whose advance I am not certain, is *Diabrotia longicornis* Say, described many years ago from examples collected near the foot of the Rocky Mountains, but which I know to now occur in Arizona and Central America. This has become a terrible pest in fields of Indian corn all over the west; and Professor Forbes, of Illinois, some years since, expressed the opinion that it was moving eastward. While mentally differing from this opinion myself, yet the fact that it was, last year, reported for the first time in Ohio, along the western border, for a time led me to feel that Professor Forbes' opinion might yet prove to be a correct one, but more recent information has shown that such was not the case, the insect having been observed in considerable numbers in western New York prior to 1880, and if there was an advance from west to east it must have been long ago.

Last year, it was reported in Ohio for the first time, and was not noticable in two or three localities along the western border of the State. This year I have found it in the second tier of counties almost throughout the entire length of the State and know that in some localities the larvæ worked some injury to the growing corn. Its congener, *Diabrotica* 12–*punctata* Oliv., though we do not know it to be of southern origin, yet it is very destructive to the same cereal in the south, but this injury, so far as known, is confined largely, at least, to the territory south of the dividing line, unless it be in Ohio, where, I strongly suspect, it is more destructive than we are aware. Of the southwest route, we have already observed much in relation to such species as have pushed their way over it from the east toward the southwest. Therefore, I shall speak only of such species, with two exceptions, American, I believe, as have passed over the ground from southwest to northeast. One of these exceptions is the larger cornstalk-borer, *Diatræa saccharalis* F. According to Mr. L. O. Howard, who has studied the species quite thoroughly, it may be a

native of the West Indies, or it may have originated in South America and made its way to the United States by way of these islands. Be this as it may, it occurs along the Gulf and Atlantic coasts, and, in the light of recent observations, it seems to be pushing its way northward along the Atlantic, having now reached the vicinity of Washington, D. C. Though for years known to infest both sugar-cane and maize, in Louisiana, yet we have no information of a corresponding advance northward, This, in some respects, appears to be the case with another insect, *Cylas formicarius* Fab., which breeds in the sweet potato, a native of Cochin, China, India and Madagascar, but introduced into the United States, probably, by way of Cuba. This may have been introduced either in Florida or Louisiana, as it occurs in both States, and is now pushing its way west across Texas. Whether it will follow in the path of the Diatræa, along the Atlantic, remains yet to be seen. They are both slowly making their way along our great southwestern highway, and if either reach Ohio it will most likely be the Diatræa and along our southern border. The Harlequin Cabbage Bug, *Murgantia histrionica* Hanan, is known to occur as far south as Gautemala, through Mexico, and first came to notice in destructive numbers in Texas about 1866. Four years later, it had pushed north to Missouri, and in 1875 it had made its way to Delaware, and on the west occupied wholly or in part Arizona, Nevada, California, Indian Territory and Colorado. It is now found in extreme southern Illinois- Indiana and Ohio, in all cases, I believe, near the dividing line between the two routes, also in New Jersey, thus covering almost exactly the southwestern highway, but, excepting, perhaps, in the far west and near the Atlantic, not extending far beyond it. Although an older established species, *Dynastes tityus* Linn., occupies almost exactly the same area except in the extreme east, where Dr. Lintner has recorded it at Kingston, some seventy miles north of New York City. To my personal knowledge it breeds in southern Illinois, and also at Bloomington, Indiana. I have found it at Columbus, Indiana, and have good evidence of its occur, rence in the vicinity of Columbus, Ohio. It has been reported from southern Pennsylvania, and, later, from New York. Of the Bag or Basket worm, *Thyridopteryx ephemeræformis* Haw., also a southern species- I only know that it breeds in southern Illinois, Indiana, and in Ohio, a short distance north of Hamilton, Butler county, while under Atlantic influences, it is sometimes abundant as far north as New York and found also in Massachusetts. The Praying Mantis, *Stagmomantis carolina* Linn., breeds in extreme southern Illinois, and also in extreme southern Indiana, but is said not to do so in Ohio. I have a male, given me some years since by Professor S. S. Gorby, State Geologist of Indiana, that was captured in a railway coach, running between Cincinnati, Ohio, and Indianapolis, and was captured between the latter city and Dayton, Ohio. I also learned that a female had been captured in Indianapolis, by which I judge that these two southern species are hovering in the vicinity of our boundary line.

We have in the country another group of destructive insects whose original habitation we are unable to determine, from the fact that their present distribution is so extended that they are liable to appear in almost any country, and even now may be present but unnoticed; in other words we know not from whence they came or whither they are going. The Corn or Boll Worm *Heliothis armiger* Hubn., is a good example of this group, as it occurs all over the United States south of lat. 44, north, in Mexico, Venezuela, Brazil, Buenos Ayres, Patagonia, Jamaica, Barbadoes, Cuba, England, Isle of Wight, France, South Africa, Cape of Good Hope, Congo River, Madagascar, Cape de Verde Islands, Azores, Bengal, North India, Mauritus, Ceylon, Java, Japan, Australia, New Zealand, and the Navigator Islands. When, or from what direction it came to us in Ohio, it is obviously useless to attempt to determine. The Clover-Hay worm, *Asopia costalis*, Fabr., is a native of Europe, but generally distributed over North America from Canada to the Gulf of Mexico. In Ohio, it seems to limit its destructiveness to the northern portion of the State, for reasons that I am unable to explain. The American Plum-borer, *Euzophera semifuneralis* Walk, was first described from Columbia, South America, but is now known to infest the country from Canada to Florida westward to Texas and Washington. In Ohio, I find it about Cincinnati, and reared it from black knot from Wayne county. It is injurious to the plum, and its depredations were first observed in Illinois, by Prof. Forbes.

Again, it is very difficult in many cases to determine just when a species first enters a given territory, as, in some cases they will remain for a long time without attracting any attention whatever by their injuries, while in others they will begin to devastate as soon as they appear. A very good illustration may be found in the Mediterranean Flour Moth, *Ephestia kuehniella* Zell, which sometimes over runs flouring mills, its larvæ becoming so abundant as to ruin the contents of the mills. Now we find it difficult to determine just whereabout in the world it primarily belonged. In this country, it first appeared in a mill in Canada, the next we hear of it is in California. It may at present be in Ohio, yet I have no knowledge of it. It seems to have appeared in Paris, France, in 1840, and in a steam flour mill in Constantinople in 1872, and at Halle, Germany, in 1877, and it also occurs in England. Two years ago, a very interesting little parasite, *Encyrtus flavus* Howard, was reared by myself from the Broad Scale, *Lecanium hesperidum* Linn.

This scale is not only generally distributed throughout the United States, but is found also in England, Europe, Asia, Africa, and Australia. It was described by Linnaeus in 1735 in his Fauna Suecica and in his System of Nature he states that it "infests evergreen and greenhouse plants." In Europe it is more especially abundant on the orange and ivy. In South Africa, according to Miss Ormerod, it is known as the "Broad Scale," and is said by Prof. P. MacOwan, of Cape Town, to seriously affect the orange trees. In Australia, it is said by Mr. Tryon, of Bris-

bane, to be very common on garden shrubs. Its injury in Asia is recorded by the late E. T. Atkinson in the Journal of the Asiatic Society of Bengal. In New Zealand, Mr. W. M. Maskell says it is the commonest species of the genus in that country, being found everywhere on ivy, holly, camelia, orange, laurel, myrtle, box and many other plants, both out of doors and in greenhouses.

The scale has, in this country, several minute parasites, *Coccophagus cognatus*, How., C. *vividus*, How., C. *flavoscutellum*, Ashm., *C. lecanii*, Fitch and *Trichogramma flavum*, Ashm. *Encyrtus flavus*, Howard, was described twelve years ago, from specimens received from California, and had not prior to my rearing it, been observed outside of the State.

The Army worm, *Lucania unipuncta* Haworth, occurring periodically over the whole length and breadth of Ohio, is also a resident of Venezuela, United States of Colombia and Brazil in South America, Isle of Wight, England, North India, Java, Australia where the writer heard much of its ravages when in that country in 1888–9, and in New Zealand.

A careful study of the geographical distribution of other species would, doubtless, throw more light upon the problem. Our dividing line is supposed to be correct only in a general way, as, of course, there can be no such thing as an exact or continuous line of demarkation. This will of necessity be more or less irregular. Again, a species spreads over an area particularly adapted for its occupancy. But no sooner is this done, than the individuals along the frontier begin to adapt themselves to an environment but slightly unfavorable, and, as their adaption changes, so do they slowly advance outward from the territory originally occupied. A series of favorable seasons might occasion the occupation of a wide margin of adjoining country, while a series of unfavorable seasons might sweep this tide of advance back to the place of its origin. But as the receding tide of the ocean leaves many pools of water in the depressions of rock, so will there be left in especially favorable nooks a few of the insects which will retain their hold and form small, local colonies, of perhaps not more than a few individuals, and the offspring of these will meet the investigator long distances from the real habitat of the species. There is scarcely a collector who does not know of one or more small, secluded areas, in his neighborhood, that are rich in varieties, and which he seldom visits without satisfaction, and frequently he is astonished at his success. How long this ebb and flow has been going on, and how many species have been brought to us in this way, are problems we are yet unable to solve.

It will be observed that by far the greater number of these immigrants have come to us from the east or south, very few from the north or west, even in the case of those from North Europe and Siberia There is, however, an intimate relation between the insect fauna of Siberia and Alaska, as has been pointed out by Dr. Hamilton, who thinks, and with reason, that the area now occupied by the Behring sea was once

dry land, and possessed a more temperate climate than at present. These Siberia-Alaskan species do extend their way southward along the mountain regions as far as New Mexico, but they do not come eastward, but, in many cases meet there the westward bound tide from the east. It was not far to the south of this that the wily Spaniard, coming too from the east, in his greedy search for gold, came in contact with a civilization, strange to him, though little inferior to his own. In the canons and caverns of New Mexico and Arizona, the Anglo-Saxon meets with the abandoned habitations of an extinct race. These may be only so many coincidences, but one can hardly help wondering at their similarity. Quite apropos to this subject comes the interesting statement of Dr. Henry Skinner, of Philadelphia, who in a recent note in the Canadian Entomologist for October, 1893, speaking of the distribution of Lepidopterous insects says; "In the species that fly from the Atlantic to the Pacific, and also exist in Europe, it will be found that the Pacific Coast examples far more closely resemble the European ones than those individuals found on the Atlantic slope.

While close commercial relations and transportation facilities have much to do with the diffusion of insects over the face of the globe, there are yet other influences at work that are little noticed by the ordinary man or woman. Rev. Dr. Henry C. McCook, in his most admirable work on American Spiders and their Spinningwork, a careful, conscientious production in commendation of which scarcely too much can be said, has clearly shown that the winds may have much to do with the distribution of insects, as I have later indicated in the case of the Cloverleaf weevil. In volume II, the author has shown that the general distribution of the Huntsman Spider, *Heterapoda venatorius*, covers with remarkable exactitude the belt over which the north and south trade winds blow. Through the courtesy of the Author, I am able to reproduce here the illustration used by him on page 271, Vol. II, of his work.[50]

Strictly speaking, spiders are not insects and the Huntsman spider has the advantage in that it spins a large mass of web which is so exceedingly light that the maker is readily wafted about in the air, supported by its balloon-like production. While this of course gives it an advantage, in the matter of transportation, yet the fact that many insects are blown about and even transported long distances, is witnessed by the occasional swarms of butterflies observed at sea, and the showers of grasshoppers and other insects that sometimes occur on land.

It is not the intent of this paper to enter into details of the distribution of species, but the questions so often asked by farmers, where do the insect pests of their crops come from, and are not new ones appearing each year? seem to warrant the explanations given in the foregoing. With our present laws, it is impossible to prevent the spread of these

[50]American Spiders and their Spinningwork. Vols. I–III, Philadelphia, Pa., Rev. Henry C. McCook, author and publisher.

and other species over our country. For the present, we can only watch for them and be prepared to meet them with measures for destruction and prevention when they appear. Therefore it is the very best of practices to report to the proper authorities the appearence of any strange or unfamiliar insect that appears in any community, especially if it exhibits any destructive propensities. Any Entomologist will be glad to give all the information in his power, free of charge.

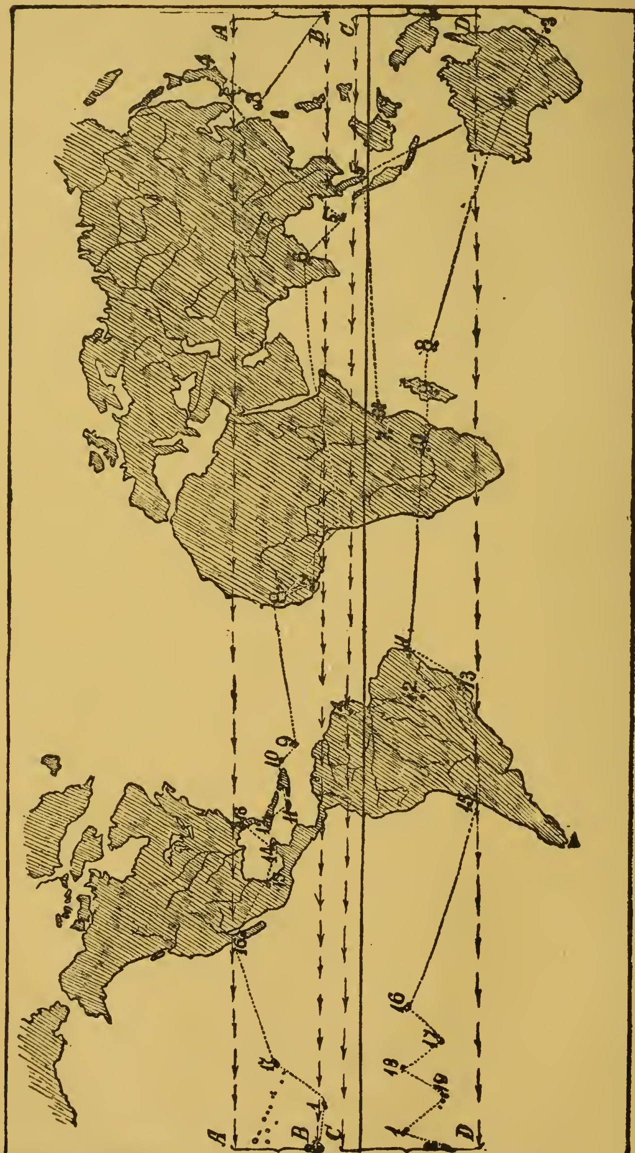

Fig. 18. Chart to show the circumnavigation of the globe by the Huntsman spider, in the course of the Trade Winds.

The heavy line in the center represents the equator, while the arrows indicate in a general way the area covered by these Trade Winds. The numbers indicate localities where the spider has been observed, and are explained as follows:

ABOVE THE LINE.

1. Palmyra Island.
2. Pelew Islands.
3. Loo-Choo Islands.
4. Japan.
5. Nicobar Islands.
6. Tranquebar, India.
7. Liberia, Africa.
8. Senegal, Africa.
9. Martinique, North America.
10. Santa Cruz.
11. Jamaica.
12. Cuba.
13. Florida.
14. Yucatan.
15. Mexico, Jalapa.
16. California.
17. Oahu, Sandwich Islands.

BELOW THE LINE.

1. Viti Levu, Fejee Islands.
2. New Caledonia.
3. Sydney, Australia.
4. Australia.
5. Singapore.
6. Zanzibar, Africa.
7. Southeast Equatorial Africa.
8. Mauritius.
9. Madagascar.
10. Zululand.
11. Pernambuco.
12. Brazil.
13. Rio Janeiro.
14. Surinam.
15. Valparaiso, Chili.
16. Tahiti, Huaheine, Society Islands.
17. Rarotonga, Cook's Island.
18. Upolu, Navigator Island.
19. Tongatabu, Friendly Islands.

INSECT FOES OF AMERICAN CEREALS, WITH MEASURES FOR THEIR PREVENTION OR DESTRUCTION.*

The three principal cereals grown in America north of Mexico, viz: maize, wheat, and oats, cover an approximate area of from 140,000,000 to 150,000,000 acres. In other words, the natural flora over this vast territory, comprising a great variety of species, has been largely exterminated, and, instead, but three have been substituted, all of which are annuals with a capacity for reproducing each year from twenty to two thousand fold. As nature is said to abhor a vacuum, so does she resent a monopoly, except it be in cases where but few species can exist, and the increase of the individuals of these is ultimately restricted by other influences, such as a rigorous climate or a barren soil. Our grain fields include neither the barren desert, the frozen mountain tops, nor the ice-clad regions of the far North, but the fertile prairies and valleys over which vegetation naturally grows in great luxuriance and profusion, each species if left to itself being kept in its proper numerical sphere by natural laws. The agriculturist, however, comes upon the scene and incites an insurrection, causing the three species before mentioned to not only rebel, but overrun and take possession of these broad acres, putting the original inhabitants to death and establishing themselves in nearly or quite full power. If the contest were wholly a natural one, the interlopers would soon be forced into their proper places, and would exist only in proportion as they could resist the returning encroachments of the natural flora. But the plow and the hoe again interpose, and the victors still hold the field. Nature then does what is naught but good generalship, brings up her reserves in the animal and vegetable enemies of the three usurping species and precipitates them upon the foe. It is here that the hand of the husbandman seems to lose its cunning. He can fight the forests, the weeds, and the grasses, but when it comes to warring upon the insect and fungoid enemies of his grains he seems to lose heart. His reserve force is, or at least should be, in his superior knowledge; but too often this virtue seems to be either sadly aborted or entirely wanting. He does not study ways to destroy or circumvent these enemies of his crops, but, on the whole, allows them to go their way, patiently taking what they leave and hoping for better luck another year.

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* Read before the Association of Economic Entomologists, at Madison, Wis., August 15, 1893, and published with the Proceedings in Insect Life, Vol. VI, No. 2, pp. 146-57, 1893.

It is here that I wish to take up my subject and show how many of the insect foes may be either destroyed or prevented from inflicting serious injury. The field of applied entomology is not the science of killing insects, alone, but includes also the warding off of their attacks. For my own part I would reverse these terms, as it seems to me that the evasion of an attack is ordinarily the most important. I would put it in this way: Warding off the attacks of injurious species by preventing their breeding, and, in case this is not practical, destroying them either before or after the attack had begun. And I may be allowed to here make use of an oft-quoted adage, "An ounce of prevention is better than a pound of cure."

There are upwards of 140 species of insects affecting these three grain crops, and maize alone has over 100 insect foes, a number of course depredating alike upon all three. Of these, such as infest the stored grain excepted, there are very few whose attacks can not be far more easily warded off than remedied after they have begun. I know of no better insecticide than good farming.

THE HESSIAN FLY.

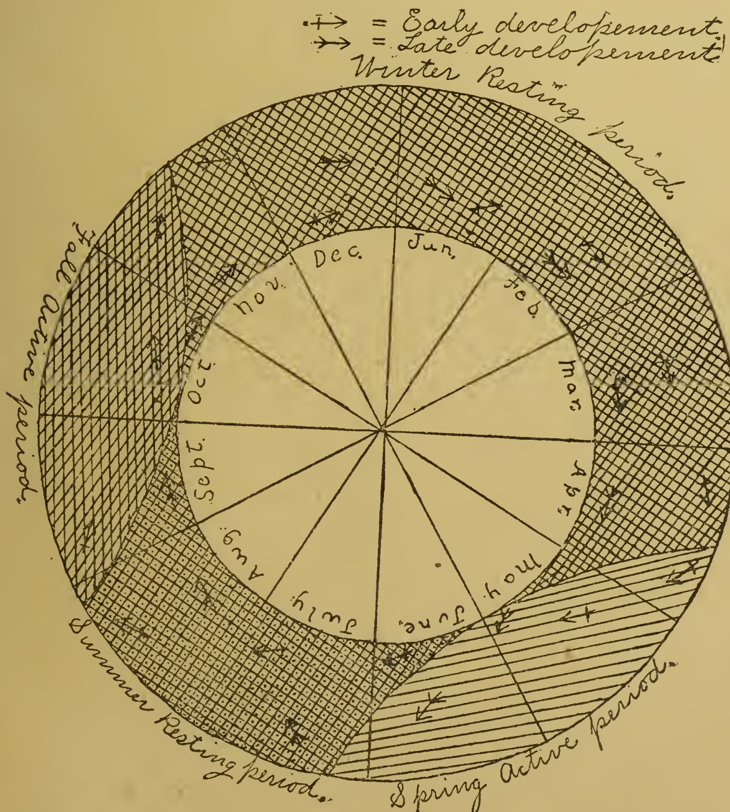

FIG. 19. Illustrating the annual cycle of the Hessian Fly.

It will be noticed that the arrows alternate from the outer to the inner edges of the circle thus: The arrow indicating the late development of larvæ in November, crosses to the inner edge at May, indicating that the adults from these will appear late the following spring; while larvæ entering flaxseed stage in October develop adults early the following spring—the arrows in this case crossing from the inner to the outer edge of the circle.

After eight years of study of the Hessian Fly (*Cecidomyia destructor*), I am satisfied that four-fifths of its injuries may be prevented by a better system of agriculture. For years I have seen wheat grown on one side of a division fence without the loss of a bushel by attack of this pest, while on the other side the crop was almost invariably more or less injured. No effect of climate, meteorological conditions, or natural enemies could have brought about such a contrast of results. The whole secret was in the management of the soil and the seeding. In fact, the question of success in evading the pest, in the one case, did not appear to be an entomological one at all; and I am fully convinced that the Hessian fly problem, so far as it relates to agriculture, throughout that portion of the country lying between the Allegheny Mountains and the Mississippi River, and between the Ohio River and the Great Lakes, may be considered practically solved.* As applicable to this area, I have attempted to illustrate in Fig. 19, and also in Fig. 20, ideographically, the annual cycle of this insect, which can of course be only approximately correct for any single locality, there being a variation of nearly if not quite one month in the season of development between the northern and southern boundaries. It will be observed that there are four seasons in this cycle, two of activity and two of inactivity, or, we might term the latter resting seasons. Over this area the winter resting season is by far the longer, while the two active seasons are about equal. Toward the south I believe the winter season will be found to be shorter and the summer season lengthened until they become equal, while to the north I confidently look for the autumn season of activity to wholly disappear and the species found to be single brooded. (See Fig. 20.)

Heretofore we have told people that the fly could not exist except where fall wheat was grown. But this can be said no longer, as the pest occurs in North Dakota and in a locality where fall wheat is never sown. Since the fall brood of flies emerges continually earlier as we go northward, it seems to me that we must eventually reach a point where it will cease to appear in autumn at all, and will go over until spring, a state of affairs that will easily account for the breeding in spring wheat in North Dakota. In other words, I expect to find that nature has protected the species alike from the protracted northern winter, and the equally prolonged southern summer, by varying its resting season with the latitude, and, possibly, also with its proximity to the sea coast. That is, we shall

* See bulletin of this Station for November, 1891.

find the insect passing both the hot and cold seasons largely in the flax-seed stage, that being the stage of development during which it is best protected from the elements and lack of food.

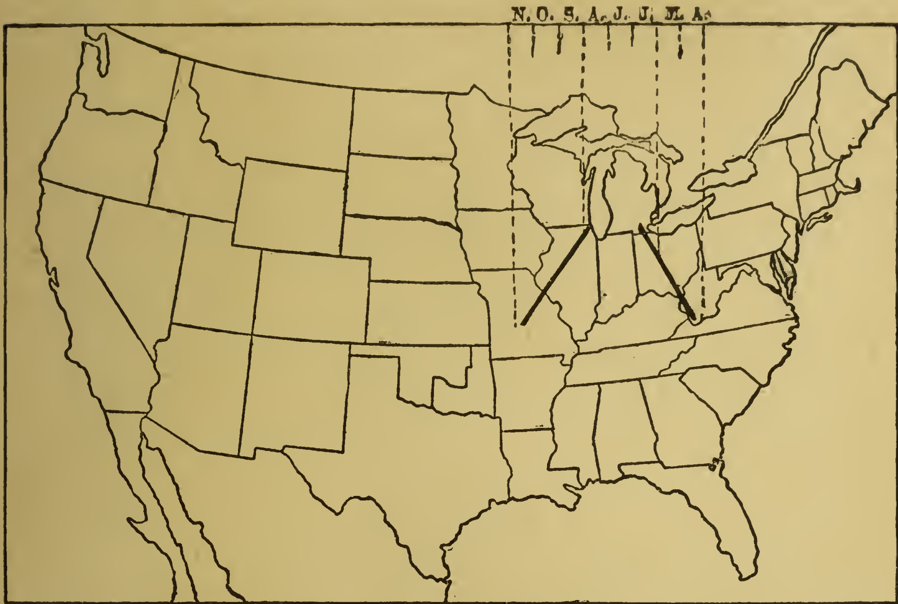

FIG. 20.—Illustrating the divergence of the two annual broods of the Hessian Fly with reference to date and latitude; the letters at upper margin, N, O, S, J, J, M, A, indicate the months from April to November while the heavy, oblique lines represent the diverging of the two broods to the southward and their approach to each other northward.

There are several good reasons why we might expect the fall brood to become extinct to the north, while the spring brood continues, the principal one being that there is not sufficient time for the former to develop before the cold season begins. Besides, in the continuity of the species it can best be spared, and I understand it is not present in England. In nearly all cases where a species is two-brooded, the spring-appearing brood of adults is the producing, while the fall is the diffusing brood. The spring-appearing flies are loth to leave the field in which they originated, and prefer to oviposit on the tillers of the wheat plant, while the autumn-appearing adults will spread out everywhere over the country, and will seemingly, scent out a field of wheat at long distances. They can even be drawn to very small plots in the midst of large cities. With the Aphides the winged female produces fewer young, but spreads them over a larger area. In the Wheat Straw Worm, *Isosoma tritici*, the spring brood of females has so far followed this rule in the past that their wings are either entirely absent or aborted, while the summer brood, *grande*, has invariably fully developed wings, and is the diffusing brood. The Army Worm, *Lucania unipuncta*, is destructive through one brood only,

the fall brood being far less gregarious. This is also true of the Chinch Bug, *Blissus leucopterus*, though in northern Indiana and northern Ohio I find the larger part of the adults with aborted wings. The spring brood of Hessian Fly, coming as it does from plants that will continue through a sufficient season for their progeny to develop, has no need to migrate, while those that summer in the stubble must necessarily change, as the plants can furnish no further nourishment; besides, diffusion and differentiation serve, in a measure, to protect from natural enemies. But notwithstanding this, it will be easily observed that the later brood can be best dispensed with without material and permanent injury to the species. This appears to me to be a state of affairs that we may look for. I do not wish to be understood as making the unqualified statement that these conditions do exist, and only hope that readers of this bulletin, located to the north and to the south of the area indicated, will be able to prove either the truth or fallacy of my position. We have much yet to learn in regard to this Hessian Fly, and a study of it in any locality would probably develop some new features, or at least new parasites.

The Straw and Joint Worm.

There are some facts connected with the two species of Isosoma, *I. tritici* (the Straw Worm), and *I. hordei* (the Joint Worm), that, to me at least are rather puzzling. Unless an undetermined species, found in New York by Dr. Lintner, proves to be *tritici*, I am not aware of its occurring east of the Allegheny Mountains, though it reaches west to the Pacific coast. On the other hand I never saw *hordei* in Illinois or Indiana, nor did I find them in central Ohio, yet I had not been a week in the northern part of the latter State before I found them in abundance. They occur, generally, over the north portion of the State and into Michigan. Is it not possible that *hordei* is of northern origin, where the season is too short for two broods, while *tritici* has pushed up from the south, where the protracted vernal season is favorable for the development of two broods? I find that *hordei* almost invariably selects small wheat plants in which to oviposit, while the summer brood of *tritici* as invariably selects large, thrifty stalks, usually where the plants are thin on the ground but rank growing. In northern Ohio I never find *hordei* far below the upper joint, an exceptional feature I believe, though it seem to me we might look for such a state of affairs, as it oviposits during a season intervening between the spring and summer broods of *tritici*. Then, too, I notice the parasites of *hordei*, at least *Eupelmus allynii* French, *Semiotellus chalcidiphagus* Walsh, and *Websterellus tritici* Ashmead, emerge in August and oviposit in the same straws from which they themselves emerged, the adults from these emerging in spring. I have also noted the same thing in the two former species where their host was a Hessian Fly. In both instances, however, I got fewer parasites in spring than in August.

So far as measures for their control are concerned, *tritici* can be largely overcome by a rotation of crop, while both this and *hordei* will be destroyed by burning the stubble, a measure equally applicable to the Hessian Fly and Wheat Stem-maggot, *Meromyza americana*.* In some portions of the country, however, clover is sown among the young wheat in early spring, and a burning over in summer under such conditions is impracticable.

The Chinch Bug.

I wish to call attention to a few points in reference to the Chinch Bug, *Blissus leucopterus*. The area of extreme continued injury by this pest covers southern Minnesota, southeast South Dakota, much of Nebraska and Kansas, all of Iowa, and much of Missouri, Illinois, all of Indiana except northeastern portion, extreme southwest Ohio, and northern Kentucky (Fig. 4), though in the wheat region of the Mississippi Valley the pest is by no means limited to this area, nor does it confine itself to the wheat region at all.

FIG. 21. Showing area of continued serious ravages by Chinch Bugs. (Webster del.)

It is more abundant in Louisiana, where wheat is never cultivated, than in northern Ohio, where this cereal is one-half of the grain crop. When it was working its greatest havoc in southern and central Illinois and southwest Indiana, I looked in vain for it in northern Indiana. I do

* For full description of insects affecting the wheat plant the reader is referred to Bulletins of this Station for November, 1891, April, 1892, and No. 46, 1892.

not understand why it is that a very large per cent. of the adults found in Ohio, along Lake Erie, and in Northern Indiana possess only aborted wings; yet I have found this to be the case. The insect parasites of this species are very few and of little account in holding it in check. For aid in this direction we must look to meteorological conditions unfavorable to its increase and the fungoid and bacterial parasites. These last will be found available during some seasons and within a certain limit, but nature is not likely to use one of her servants to annihilate another. We may be able to emphasize their work in this direction by continual artificial cultivation and distribution; further than this we cannot expect to go, and the relief will at best be but local and temporary, though not by any means without value in limited areas. The only difficulty is in that we cannot foretell a year of destructive abundance with certainty, and a few false alarms will so discourage the ordinary farmer that he will do nothing to protect himself. For my own part I feel quite sure that if the bugs can be induced to oviposit in spring in small plots of millet or Hungarian grass they can be controlled by the use of the bacterial and fungoid diseases to far better purpose than to attempt to do so in the fields of ordinary cultivation. But there must be, somewhere, a central source of supply where requests for material can be promptly filled, as has been done by Prof. Snow, before the plan will prove a success. Next in value to such plats is, I think, the cornfields where the bugs must of necessity congregate in compact masses and thus facilitate contagion.

Plant Lice.

It would appear almost visionary to advocate spraying apple orchards in midwinter to protect the wheat crop, but nevertheless one of the most serious enemies of young fall wheat passes its egg stage on the twigs of the Apple during the winter season. I refer to the Apple Leaf-louse, *Aphis mali* Fab. Soon after the young wheat plants appear in the fall the winged viviparous females of this species flock to the fields and on these give birth to their young, which at once make their way to the roots, where they continue reproduction, sapping the life from the young plants. On very fertile soils this extraction of the sap from the roots has no very serious effect, but where the soil is not rich, and especially if the weather is dry, this constant drain of vitality soon begins to tell on the plants. Though they are seldom killed outright, these infested plants cease to grow, and later take on a sickly look, and not until the Aphis abandons them in autumn to return to the Apple, do they show any amount of vigor. It is very seldom that the affected plants fully recover, at least in autumn, and the result must be to reduce their productiveness the following year.

Corn Insects.

The greater number of serious pests of our fields of Indian corn are such as work their injury below the surface of the ground. Wire worms devastate our lowlands and the White Grub ravage the higher lands, while Cutworms, Web Worms, and Corn Root-worms are found generally diffused over both. The Corn Root-worm, *Diabrotica longicornis*, excepted, all of these seem more destructive to a crop of grain following a grass crop or pasture. Yet this is not always true. I have known of fields of corn being seriously affected by white grubs when such fields had not been devoted to grass for a single season in twenty years.

In the case of Wire Worms some good results may be secured by fall* plowing, though as the adults emerge in August or September and winter over, also in this stage, we can hope to do little with these. There are, however, during the winter two younger generations in the soil, and against these a fall plowing may and evidently does have an ill effect. What a summer fallow would do I have had no opportunity of learning. There is no end of reported successes and failures among farmers, but there is so much obscurity shrouding these that one cannot judge of their authenticity. Once, and only once, have I felt quite sure of having beaten these pests. This was in the case of a field of grass land, plowed in spring and planted with potatoes. The worms nearly ruined the crop, and in the fall the ground was still well populated with them. The following spring, potatoes that had escaped notice when the crop was harvested seemed to attract the worms, and the latter were found burrowing in the tubers in great numbers. On my suggestion, hogs were turned into the field, and these rooted out and promptly disposed of both potatoes and worms, no injury occurring to the following crop, which was of corn. There may be some virtue in the application of kainit, although this has not as yet been thoroughly and clearly demonstrated, and, besides, over the vast corn belt of the Northwest, its application is impracticable. For myself, I am willing to confess ignorance of any unfailing, practical measure, either of prevention or destruction. Fall plowing and a rapid rotation of crops are as yet the best measures we can recommend.

White Grubs, the larvæ of several of our species of Lachnosterna, appear to give preference to the higher lands. Where the soil of such lands is of such a nature as to wash easily during winter and spring, fall

*Note: This statement is based on the fact of adults being found above ground in the fall and under boards and similar objects in early spring, before the ground has thawed to any depth. Mr. M. V. Slingerland, of Cornell University, has kindly called my attention to a statement appearing in Bulletin 33, of the University experiment station, to the effect that the adults develop in the summer but do not appear above ground until the following spring. I think that my own statement may, perhaps, be modified slightly, as it is very possible that some individuals emerge in the fall while others do not. However, they are altogether too numerous above ground in the fall and winter to warrant the statement that they do not emerge in summer and autumn.

plowing results in the washing out of great gullies, thus constituting a grave objection to the measure. Outbreaks of this pest seem to be usually of triennial occurrence, different localities being affected during different years, and I have thought we might accomplish something by mapping out these areas, and so warn the agriculturist of their probable appearance. Here, however, the same trouble awaits us. A single mistaken prediction discourages the few who will follow our direction, and we get only derision from the remainder. In my own correspondence I have advocated the same measures against these as in case of the Wire Worms, viz., a rapid rotation of crops, especially of grass or clover, and fall plowing, whenever it can be done without detriment to the fields. What has, or is likely to be accomplished by the use of fungoid parasites, I do not know. As in the case of the Corn Root-louse, *Aphis maidis* Fitch, or *Aphis maidi-radicis* Forbes, less injury is done in fields that have been fertilized with barnyard manure.

The Corn Root-worm, *Diabrotica longicornis* Say, has by its ravages cost the farmers of the Mississippi Valley millions of dollars during the last fifteen years, every penny of which might have been saved by a judicious system of husbandry. In Ohio it is unknown, except along the western border of the State. Its occurrence here, where it was reported last year for the first time, raises the question of its eastward diffusion—a problem which I hope to be able to solve. The congenor of this species, the Southern Corn Root-worm, *Diabrotica 12-punctata* Oliv, will certainly not be managed so easily. There is yet some investigation to be done on this species, before we can confidently advise in regard to its destruction. It appears, in the adult stage, to be well-nigh omnivorous, and the larvæ travel freely.

The corn or Boll Worm *Heliothis armiger* Hbn., is more especially a Southern species, though as far north as Chicago there are, during some seasons, two broods, as, in that portion of Illinois, I have found half grown larvæ in the ears of ripe corn, in November. In the North the damage done is trivial, often being due to the rain and dew running into the affected ears, causing them to decay. Among the market gardeners, where it works in the sweet corn, the measure suggested by Prof. French, several years ago, which was late plowing in the fall, will do much to hold the species in check. In the South the most sensible and practical suggestion that I have seen mentioned is to plant corn early amongst the cotton in order to attract the early brood of worms, and then destroy the corn in a way to kill the depredators.

For the major portion of the cutworms, I have much faith in laying down of poisoned grass or clover baits, but the larvæ of *Hadena devastatrix* Brace and H. *stipata* Morris, cannot be reached in this manner, as they do not come to the surface to feed. The first eats the plants directly off a short distance above the roots, while the last eats into the stem at about the same place, then tunnels its way upward, eating out the heart after the manner of the Stalk Borer, *Hydræcia nitela* Gn.

A New Corn Insect.

I have here to introduce a third species of Hadena, *H. fractilinea* Grt., an entirely new depredator in our cornfields, at least so far as published records are concerned. In fact we rarely find the species mentioned at all in our entomological literature. The imago was described in the *Canadian Entomologist* (Vol. VI, p. 15, January, 1874), the habitat there being given as Canada (Petit), Albany, N. Y., (Lintner). Prof. G. H. French, who first determined the species for me, has it from Maine and New York, and Prof. John B. Smith has it from Maine to Ohio, Minnesota to Colorado. How far south it extends I do not know. The adults are so exceedingly quick in movement and secluded in habit that it is not surprising that it should be overlooked. Several specimens of both sexes that were transferred from the cage in which they were reared to another in which grass was growing were not observed afterwards.

FIG. 22. Adult of *Hadena fractilinea*. Life size. From photograph by F. J. Falkenbach, Ohio Ex. Station.

The habits of the larvæ are in strange contrast with those of *stipata*, at least in the cornfields, where that species work entirely below the ground, entering the stem just above the roots and eating its way upward, while in this species they climb up the plant and eat downward, devouring the whole interior of the stem down to a point where the *stipata* would begin. If the plant be a young one—that is only two or three inches in height—these larvæ will enter the cylinder formed by the youngest leaf, but if the plant be older and tougher they will eat downward along the edges, as shown in Fig. 5, until the tissue is more tender, when they will enter the stem and work downward. The time of oviposition I am unable to give. Larvæ, from two-thirds to quite full grown, were taken the last of June, when they were said by the farmers to be disappearing. From these larvæ imagoes appeared *in the insectary*, the last days of July and up to the 10th of August. I did not observe them, nor can I learn of their occurrence elsewhere than on spring-plowed grass land, and this either

FIG. 23. *Hadena fractilinea; a*, lava ; *b*, pupa—nat. size.

wholly or in part timothy sward. There appeared to be no difference in point of injury between early and late spring plowing. There did not appear to be any disposition on the part of the larvæ to wander about, but if the corn was planted in hills, after finishing one stalk they would abandon it and attack another, and so on until all were destroyed.

Description of the Larva. (Fig. 23, *a*).—Length 26^{mm}; color, yellowish white, two dark, broad, dorsal stripes separated by a narrower light stripe of the general color of the body, the dark stripes extending from the anal segment forward, unbroken, to the first thoracle where there are one or two narrow, sharply defined interruptions, also of the general color of the body and near the anterior margins of each of the thoratic segments, thereby dividing the dark stripes unequally, the anterior portion being little wider than the interruption. Cervical shield honey yellow, uniform in color with the head, but rather lighter than the anal shield. A rather narrower and darker lateral stripe extends from the head to the anal segment, its lower margin being on a line with the spiracles. At the posterior extremity of this lateral stripe, just above and slightly forward of the anal proleg is a round, dark-brown dot from which originates a short, hooked bristle; just beyond this dot and extending around the posterior margin of the anal segment to a corresponding point on the opposite side and just under the slightly projecting anal extremity is a continuous row of four connected dots of the same dark-brown color and each producing a short, curved bristle, all slightly curving upward. The head is small, rather less than the anal segment with the mouth parts well developed and very dark brown in color, being smaller than the first segment in about the same proportions as the anal segment decreases in size from the one that precedes it and the coloration and markings being so nearly alike, it is not an easy matter to distinguish the two at a glance. From the second to the ninth segment there is little variation in the size of the body, it being rather slender until near the time of pupation, when it increases somewhat in size anteriorly.

Description of the Pupa. (Fig. 23, *b*). Length 14^{mm}, greatest diameter 4.5^{mm}. There are no teeth or spines except at tip, where, extending from near the dorsal tip of the last segment are two horizontal, short, robust, blunt appendages, parallel, but flanked on each side by a very slender, hooked appendage, exceeding in length the former but of a lighter color. Just beneath these on the ventral surface, is a short deep slit, the edges and vicinity of which are very dark brown. The general color does not differ from that of other allied species.

The larvæ from which all my adults were reared, were taken from corn plants either in the field, or from plants sent me by my correspondence, and I saw every one of them in transferring them to the breeding cages. All were working in corn in precisely the same manner and there was certainly no noticeable difference in the larvæ. The imagoes, however, were those of two species, as they are now understood, the larger number being the one under consideration, while the remainder were *Hadena misera* Grt. If, therefore, the two species are distinct, then this also must be added to the list of corn destroying insects, and a further study will be necessary to separate the larvæ, whose depredations appear not to differ. Prof. Smith writes me that he has this last species from Colorado, taken by Bruce, and also from Minnesota, bred by Prof. Lugger. All this, of course, does not disprove the validity of the species, as, if I

remember rightly, there is a strong resemblence between the larvæ of *H fractilinea* and *H. stipata*, as I observed them in corn in Indiana some years ago.[51]

My attention was first called to the depredations of these cutworms in Ohio, by Mr. C. H. Coon, of New Lyme, Ashtabula county, and it was while I was spending a day with him in response to his letter of inquiry that I found the pest and was enabled to study its habits, to a limited extent. Later, I received specimens from Mr. D. H. Blake, of Chapel, in the same county, with the statement that they were common and destructive in his neighborhood, working on land that had been in timothy the preceding year, clover sod being less or not at all affected. In my own observations this appeared to be the rule, as was also their non-appearance on fall plowed ground except where such ground bordered on a field of timothy, in which case a few worms might be found ravaging the first two or three rows of corn along this border. A very similar case of preference for timothy in a closely allied species, *Hadena devastatrix*, came under my observation in Indiana some years ago, where the larvæ destroyed whole acres of the grass leaving the clover growing among it untouched[52].

The various species of web worms, larvæ of several species of Crambus, are, of late, working nearly as much damage in our cornfields as are the cutworms, and are even less accessible. The larvæ of at least three species have this season devastated the cornfields of eastern Ohio, one of which appears to feed below ground exclusively. For my part, I am puzzled to know how to deal with these. Can it be done by breaking the sod in early summer, and allowing the wind and sun to dry out and kill the grass roots, thus starving the very young worms? The plan of breaking the ground very late in spring and planting the crop immediately I find often fails of protection.

ACKNOWLEDGMENTS.

Figs. 2, 3, 10, 16 were secured through the aid of Dr. J. A. Lintner.

Fig. 9 was secured through the kindness of Prof. Bruner.

Fig. 13 was purchased from Prof. C. V. Riley.

Fig. 18, loaned by Rev. Henry C. McCook.

Figs. 19, 20, 21, 23 were secured from the U. S. Department of Agriculture, the drawings having been furnished by this Station, and were made by Miss Vinnie Cunningham, under supervision.

Figs. 14, 22 were photographs from life by F. J. Falkenbach, of this Station.

[51] Insect Life, Vol. II, p. 383.

[52] Rept. Comm. Agr , 1886, p. 578.

SUMMARY.

The Asparagus Beetle is an imported insect feeding in both the larval and adult stages on asparagus. It appears to be slowly extending its area of attack to the west and south, and is establishing itself in Ohio. There are several generations each year, the pest wintering in the adult or beetle state. Sowing lime over the asparagus beds in the morning, while the dew is on, and the application of pyrethrum to the plants while the insect is in the larval stage, are the best remedial measures.

The Western Corn Root-worm is the larva of a small green beetle, a near relative of the striped squash and cucumber vine beetle. The eggs are laid about the roots of corn in late summer and fall and hatch the following spring or early summer. If corn follows corn on the same ground year after year these worms will continue to increase and feed on the roots of the corn plants. The effect of these worms on the roots is to destroy them and thus wholly or in part destroy the crop. A rotation of crops from corn to any of the small grains or grasses is a perfect protection.

The Broad-striped Flea-beetle is a small jumping insect, striped somewhat like the squash and cucumber vine beetle, but is very much smaller, and more active. The pest is supposed to breed in the ground, and is not usually abundant enough to cause serious injury. Dusting the plants being attacked with Paris green mixed with flour, and applying kerosene emulsion are the remedies.

Blister Beetles: There are five species of these common to Ohio, four of which are more or less destructive. They all breed in the ground and while in the larval stage are carnivorous, feeding to some extent on the eggs of grasshoppers, and are to this extent to be considered beneficial. It is difficult to find a remedy against their attacks, as, while poison doubtless kills some of them when it is thoroughly applied to the vines of potatoes being attacked by them, the effect is so slow and there being a continual influx from outside it is well nigh impossible to thus cope with them to advantage. Driving them on to patches of straw laid down along the edges of the fields and burning this is the most effective. It is possible that spraying with Bordeaux mixture may be a protective measure.

The Bag or Basket-worm occurs only in the southern part of the state, not extending northward to Columbus. It belongs to the same order of insects as the butterflies, but the male only possesses wings, and the eggs are not deposited on vegetation by the female, but within the bag or basket and the young make their way out. The bags or baskets from which these caterpillars take their name are begun as soon as the young emerge from that occupied by the mother, and are enlarged to conform to the growth of the occupant, as the season advances. There is but a single annual brood, the males emerging in the fall and the young hatching from the eggs in the following June. The pest can

be destroyed either by collecting the bags or baskets during the fall, winter or early spring, or by spraying the trees late in June with Paris green or London purple, as for the codlin moth.

The Cabbage Aphis: This, too, is an imported species that has become naturalized in this country, affecting cabbage, turnips and others of this group of vegetables. The insect winters over, largely at least in this latitude, in the egg state. In the spring these eggs hatch fertilized females which reproduce by giving birth to their young after the manner of animals, the young themselves developing and reproducing within a few days after being born, all young produced being females. Late in the fall, there is a generation produced in which there are both sexes, and of these, after pairing, the males die and the females deposit eggs, after which they also die. The remedies for these are tobacco dust and kerosene emulsion.

The Apple Plant-louse: This belongs in the same group of insects as the preceding, and reproduces in the same manner. In this case, however, the eggs are deposited in the fall on the twigs and limbs of the apple, hatching in spring into the small green lice so noticable on the young buds in early spring when these are being first put forth. Later, they desert the tree and go to the weeds and grasses. After the young wheat is well up in the fall the lice congregate on the young plants and reproduce, and the young, descending to the lower part of the stem, continue reproduction and, when abundant, do some injury to the plants. The only place to fight these insects is on the apple trees and with kerosene emulsion.

Lines of Insect Immigration: There appear to be two great highways which insects imported from Europe have followed in entering Ohio. Those coming from north of latitude 45° north, have generally entered the State at its northeastern corner and their spread southward has, as a rule, been less marked than to the westward, while those coming from southern Europe have generally entered by way of the Ohio valley and have a comparatively restricted northern distribution.

Measures for the Control of Insects Affecting Cereals: For the Hessian Fly, late plowing is the most effective preventive yet discovered. Burning the stubble is useful in preventing the ravages of this insect, as well as of the Straw and Joint worms. For destroying the Chinch Bug, Prof. Snow seems to have used a fungoid, *Sporotrichum globuliferum* to considerable advantage. Fall plowing and rapid rotation of crops are the best measures yet discovered for preventing the increase of Wire worms and White grubs. Rotation alone will overcome the Western Corn Root Worm, and most cutworms may be destroyed by laying down baits of poisoned grass or clover.

BULLETIN

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

VOL. VI, NO. 5. WHOLE NUMBER 52. SECOND SERIES. DECEMBER, 1893.

METEOROLOGICAL SUMMARY FOR 1893.

BY F. J. FALKENBACH.

EXPLANATION OF TABLES.

The following tables contain statistics of temperature, rainfall, etc., for the year, and are compiled from data obtained by daily observations. T stands for "trace," less than .01 inch of daily rainfall. Temperature is given in degrees Fahrenheit.

Table I shows the daily rainfall at the station during the year in inches and hundredths.

Table II shows the daily mean temperature for 1893, and the normal mean temperature for each day, computed from six years' record.

Table III gives a comparison of the monthly mean temperature and rainfall for the Station and the State with the six years' average for the same.

Table IV shows the rainfall at the Station for each month during the last six years.

Table V contains the mean temperature, the highest and lowest temperature, with the range of temperature for each month; the number of clear, fair and cloudy days; the rainfall and prevailing direction of wind for both the Experiment Station and State.

Table VI contains the principal points of interest on temperature, state of weather, and rainfall for the Station, during the year, and a grand summary for six years.

Table VII contains the principal points of interest on temperature, state of weather and rainfall for the State during the year, and a grand summary for eleven years.

The statistics for the State and for this Station previous to 1893 are compiled from the publications of the Ohio Meteorological Bureau and State Weather Service.

It will be observed that the statistics for the Station relate to its present location in Wayne county, and therefore are not directly comparable with those published in former reports, which relate to observations taken at Columbus.

METEOROLOGY.—TABLE I.—RAINFALL.

DAILY RAINFALL AND MELTED SNOW FOR 1893, AT EXPERIMENT STATION.

	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.39	.76	....	....	1.26	.05	....	T	....	....	....	....
2	.41	49	....	....	....	.05	....	....	....	....	....	T
3	T	....	.06	.96	....	.07	.12	....	....	.65	....	.40
4	T	....	.04	....	....	.68	....	....	....	.70	....	....
5	.10	.75	....	....	.57	T	....	....	T	....	....	....
6	.15	1.33	....	....	....	.08	.04	....	.06	....	....	....
7	.25	....	....	.13	....	....	.07	....	....	....	....	....
8	....	....	.10	T	....	....	.32	....	....	....	....	....
9	.12	1.32	.12	T	....	....	....	....	....	....	....	....
10	.18	....	.03	.40	....	....	.13	....	....	....	....	....
11	T	....	.40	T	....	....	....	T	....	....	....	.30
12	.55	T	.03	.21	.22	....	....	.35	.08	....	....	....
13	.05	.20	....	.06	.40	....	.30	....	.16	1.35	.04	....
14	.48	.25	.20	.13	.20	....	.11	....	....	1.60	....	....
15	T	....	T	.50	.70	.30	.05	....	....	....	....	40
16	.10	....	T	....	.99	.38	.13	.18	....	....	....	.20
17	T	.37	....	....	.42	.06	.03	....	....	....	T	....
18	T	.05	....	....	.08	....	....	T	T	....	.15	....
19	.5	.15	08	.27	....	....	....	....	....	....	....	....
20	.15	.08	....	.40	.25	.03	....	....	....	.10	....	....
21	T	.40	.20	.05	T	.15	....	T	....	....	.40	....
22	.04	T	.53	T	....	.66	....	....	....	.08	.05	.10
23	....	T	.05	....	.05	....	....	....	1.00	....	....	....
24	.10	....	.05	....	....	....	....	....	.25	....	....	....
25	.16	T	....	.32	....	....	.02	....	.20	....	....	....
26	T	....	....	.40	.57	....	....	....	....	.30	....	....
27	....	....	....	.15	....	....	....	.60	....	.35	1.50	....
28	....	.18	....	....	....	T	.06	.15	....	.05	.15	.10
29	.28	....	....	.84	....	....	....	.25	....	....	.20	T
30	....	....	....	.84	.57	....	T	....	.10	....	T	....
31	.45	....	....	....	T	....	....	....	....	....	....	....
Totals	4 01	6 33	1.89	5 66	6 28	2.51	1 38	1.53	1 85	5.18	2.49	1.50
Averages	.13	.23	.06	.19	.20	.08	.04	.05	.06	.17	.08	.05

METEOROLOGY.—TABLE II.—TEMPERATURE.

(N. stands for Normal Mean Temperature for 6 years.)

	January.		February.		March.		April		May.		June.	
	1893.	N.	1893.	N.	1893.	N.	1893.	N.	1893.	N.	1893	N.
1	34	36	35	26	32	26	53	43	64	50	70	63
2	24	24	30	27	38	27	44	41	48	51	73	66
3	12	21	24	34	33	26	58	42	46	54	76	69
4	17	22	10	32	17	24	56	41	46	55	74	67
5	15	26	31	28	22	20	55	44	47	53	75	67
6	15	27	44	27	36	25	48	41	51	54	68	65
7	14	22	15	28	39	24	73	45	48	56	64	66
8	18	26	16	26	50	29	68	45	58	57	62	66
9	18	22	33	29	46	30	48	44	63	60	66	69
10	1	24	33	22	44	29	43	46	61	60	71	67
11	2	28	30	26	44	32	48	47	68	55	66	65
12	10	27	32	28	40	32	61	48	59	55	62	67
13	7	26	34	30	50	30	64	49	53	53	64	69
14	6	23	43	31	34	29	36	52	57	53	67	68
15	4	22	40	32	19	25	35	47	58	56	72	71
16	3	23	28	37	24	27	49	46	46	51	72	72
17	1	22	28	29	32	30	44	51	45	57	72	71
18	21	24	24	29	27	32	45	52	52	63	72	71
19	8	21	17	24	31	29	48	51	59	59	73	70
20	12	17	4	24	43	30	54	49	64	58	74	70
21	17	19	15	24	44	30	42	51	69	58	74	69
22	24	18	23	26	36	29	35	50	76	61	73	68
23	28	26	33	25	62	34	40	51	56	60	66	69
24	28	26	28	34	52	33	47	45	57	63	65	69
25	24	27	24	34	34	38	45	47	63	63	70	68
26	28	27	24	28	32	37	53	53	53	59	68	67
27	27	25	39	29	34	35	52	54	62	58	65	67
28	44	29	36	27	31	32	56	51	60	57	66	70
29	33	29	...	...	38	32	50	50	62	59	67	72
30	28	29	...	...	50	36	53	54	67	63	71	72
31	33	33	...	...	56	29	...	...	68	61	...	..
Daily mean	18	27	28	29	[illegible]	29	50.1	47.2	57.6	57.3	69.3	68.9

	July.		August.		September.		October.		November.		December.	
	1893.	N.	1893	N.	1893	N.	1893	N.	1893.	N.	1893.	N.
1	69	72	72	70	63	65	52	59	52	46	22	30
2	69	73	66	70	57	66	58	57	54	47	16	32
3	69	73	68	70	60	66	62	59	46	41	28	35
4	63	69	74	71	64	65	54	55	40	41	23	36
5	72	70	72	72	72	67	56	55	36	42	20	36
6	65	71	70	70	71	66	58	53	38	43	24	35
7	78	72	62	70	78	68	62	54	46	46	18	37
8	79	71	64	69	67	63	56	52	50	47	28	36
9	69	68	69	69	68	63	65	54	48	52	30	36
10	68	70	74	70	72	64	62	54	46	47	29	39
11	61	71	78	71	70	64	67	55	48	42	28	37
12	72	72	70	70	70	65	68	54	50	39	30	34
13	79	72	64	70	70	64	59	53	36	41	22	33
14	79	72	66	69	76	66	40	47	33	38	26	33
15	82	72	69	69	76	66	40	44	25	37	47	35
16	78	72	72	68	59	64	45	47	32	38	42	33
17	76	72	70	68	56	61	46	52	40	34	24	29
18	72	69	67	67	64	61	48	49	35	36	22	24
19	68	68	64	67	74	61	53	50	34	37	26	24
20	68	67	62	67	64	60	51	47	30	36	18	29
21	68	70	66	66	68	62	54	45	34	40	28	30
22	70	74	62	66	74	62	56	45	36	42	41	27
23	70	71	67	67	60	61	57	44	26	38	47	33
24	66	69	72	68	58	60	61	46	20	36	51	38
25	77	69	77	63	50	57	46	43	21	36	56	37
26	77	71	74	68	47	58	49	45	30	36	38	32
27	68	72	70	67	49	57	45	46	37	36	32	30
28	68	71	69	66	48	58	[illegible]	48	33	27	42	31
29	78	72	59	66	44	58	34	44	38	28	42	36
30	72	71	59	66	48	55	36	41	38	28	31	32
31	76	73	56	67	...	...	38	44	...	...	28	34
Daily mean	72	70.8	67.9	67.1	63.2	62.2	52.3	49.6	37.7	39	30.9	32.4

METEOROLOGY—TABLE III.

Comparison of Mean, Temperature and Rainfall for 1893 at Experieent Station.

	Jan	Feb.	March.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Mean temperature at the station	18°	28°	38°	50.1°	57.6°	69.3°	72°	67.9°	63.2°	52.3°	37.7°	30.9°	49.3°
Six year average temperature at the station	27.6°	29.9°	34.2°	46 5°	56.3°	68.4°	70.2°	68.2°	62.0°	48.9°	39.5°	33.0°	49.7°
Mean temperature for the state	18°	29°	38°	50.2°	58.3°	70 6°	74.5°	70.7°	65 2°	53.7°	39.3°	32.7°	50.1°
Six year average temperature for the state	28.5°	32.6°	36.1	50.3°	58.9	70.4°	72.0°	70.0°	63.6	50.9°	40.8°	34.8°	50 9°
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches
Rainfall at the station	4.01	6.33	1.89	5.66	6.28	2 51	1 38	1.53	1.85	5.18	2.49	1.50	40.61
Six years average at the station	3.66	4.44	3.14	2.82	4.83	5.04	3.89	2.84	2.85	3.14	3.56	2.20	41.69
Mean rainfall for the state	2.56	5.13	2.09	6.37	4.97	3.34	2.49	2.17	1.57	4.24	2.09	2.61	39.63
Six years average for the state	3.20	3.58	3.23	3.17	4.41	4.30	3.45	3.26	2.76	2.79	3.35	2.23	39.79

METEOROLOGY.—TABLE IV.

MONTHLY RAINFALL FOR SIX YEARS AT WOOSTER.

Year.	January.	Feb.	March.	April.	May.	June.	July.	August.	Sept	October.	Nov.	Dec.	Total.
	Inches.	Inches	Inches.	Inches	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1888.	3.52	2 43	3.34	2 48	3.82	2.31	4 54	4.35	1 92	3.18	4.95	1.39	38.25
1889.	4.33	2.42	2.13	1.58	2 97	4.86	6.73	1.98	4.05	1.36	3.53	3.93	39.87
1890.	4.71	6.20	4.57	3 10	6.01	5.57	2 67	4.66	5.12	7.45	2.61	1.74	54.21
1891.	2.74	4.83	3.71	1.66	2.24	7.13	3.28	1 85	0.94	1.33	5.73	2.92	38.36
1892.	2.67	....	3.38	2.44	7.69	7.89	4.73	2.69	3.20	0.37	2.06	1.74	38.86
1893.	4.01	4.33	1.89	5.66	6 28	2.51	1.38	1.53	1.85	5 18	2 49	1 50	40.58
Averages.	3.66	4.44	3.14	2.82	4.83	5.04	3 89	2.84	2 85	3.14	3.56	2.[illegible]0	41.[illegible]9

METEOROLOGY.—TABLE V.—SUMMARY BY MONTHS FOR 1893.

	Temperature.											Number of days.						
	Mean.	Highest.	Date.	Lowest.	Date.	Range.	Mean daily range.	Greatest daily range.	Date.	Least daily range.	Date.	Clear.	Fair.	Cloudy.	Rain fell.	Monthly rainfall.	Average daily rainfall.	Prevailing wind.
At the Station.																		
January	18	51	28th.	—9	11th.	60	14	34	26th.	3	24th.	2	8	21	18	4.0	.13	S. W.
February	25	47	1*	—2	26th.	49	15	32	7th.	3	11th.	5	7	16	13	6.33	.23	W
March	38	75	23d.	10	16th	65	16	40	2[illegible]d.	4	22d.	5	12	14	13	1.[illegible]9	.06	S W.
April	50 1	83	7th.	24	15th.	59	16	31	7th.	5	10th.	5	12	13	15	5.66	.19	S W
May	57.6	84	22d.	36	24th.	48	17	32	24th.	3	2[illegible]th.	9	9	13	13	6 28	.20	S W.
June	60.3	92	19th.	45	8th.	47	24	38	19th.	10	2[illegible]d	8	22	0	11	2.51	.08	S. W
July	72	95	2*	47	4th.	48	28	40	28th.	16	26th.	10	20	1	12	1.38	.04	S W
August	67.9	93	10th.	37	31st.	56	29	45	9th.	8	2[illegible]th.	9	20	2	5	1.53	.05	N. W
September	63 2	95	7th.	28	29th.	67	26	40	4th	11	1[illegible]th.	8	22	0	7	1 85	.06	N. W
October	52.3	85	11th.	24	31st.	61	24	38	18th	6	13th.	15	12	4	9	5 15	.17	S
November	37.7	66	7th.	15	25th.	51	17	40	7th.	7	28th.	13	10	7	7	2.49	.08	W.
December	30.9	62	25th.	6	3*	56	16	29	16th.	6	2[illegible]d.	7	10	14	6	1.50	.05	S. W.
Sums and averages	49.3	77.3	....	21.8	....	55.6	20.2	36.6	....	7	....	96	164	105	129	40.58	.11	S. W
For the State.																		
January	18	63	26th.	—24	1*	87	17	52	18th.	1	4th.	5	9	17	13	2.56	.08	W.
February	29	68	14th.	—14	21st.	82	18	47	2*	2	2d.	5	7	16	13	5.13	.1[illegible]	W.
March	38	87	23d.	—8	16th.	95	21	50	25th.	2	3*	8	12	11	9	2.09	.07	W
April	50.2	93	7th.	20	16th.	73	20	53	4th.	1	4*	5	10	15	16	6.37	.20	S W
May	58.3	94	5*	23	7th.	71	23	49	20th.	1	6*	9	1[illegible]	11	11	4.97	.16	S. W
June	70 6	102	19th.	40	7*	62	24	46	19th.	2	6th.	16	12	4	9	3 34	.11	S W
July	74 5	101	16th.	42	8*	59	26	52	28th.	1	9*	15	13	3	8	2 49	.08	S. W
August	70 7	101	26th.	37	31st.	64	26	54	9th.	3	17th.	16	11	4	6	2.17	.07	N W.
September	65.2	100	7th.	24	10*	76	26	54	11*	3	20th.	13	12	5	5	1.57	.05	W.
October	53.7	95	11th.	15	28th.	81	24	50	12*	1	3d.	16	7	8	6	4.24	.14	S. W
November	39.3	76	9th.	2	26th.	74	20	45	5th.	2	8th.	10	9	11	7	2.09	.07	S. W
December	32.7	72	24th.	—5	2d.	79	18	44	14th.	1	13*	6	10	15	10	2.61	.09	S W
Sums and averages	50.1	87.6	....	12.5	....	75.2	21.7	59 6	....	2	....	122	123	120	113	39.63	.11	S. W.

Station—*1—3 10, 15. *2—7, 25. *3—17, 31.
State—*1—11, 15. *2—7, 26. *3—10, 12, 13, 22. *4—22, 30 *5—11. 20, 21, 22. *6—4. 17. *7—7, 19, 23. *8—2, 4, 11, 21. *9—1, 4, 9. *10—26, 29. *11—5, 6. *12—2, 11, 12. *13—16, 21, 26.

METEOROLOGY.—TABLE VI.

SUMMARY BY YEARS AND GRAND SUMMARY FOR SIX YEARS.

	1888.	1889.	1890.	1891.	1892.	1893.	Summary for six years.
At	*Wooster.*	*Wooster.*	*Wooster.*	*Wooster.*	*Wooster.*	*Experiment Station*	
Mean temperature	47.6°	48.6°	49.5°	50°	50°	49.3°	49.7°
Highest temperature		91.50, *1	94.5°, Aug 3	99°, Aug. 8	98°, July 25	95°, *5	99°, Aug. 8, '91.
Lowest temperature	—5°, Feb. 9	—5°, *2	1°, March 7	0°, March 1	—20°, Jan. 20	—9°, Jan. 11	—20°, Jan. 20, '92.
Range of temperature		96.5°	93.5°	99°	118°	104°	119°.
Mean daily range of temperature		18.7°	18.9°	21°	19°	20.2°	19.6°.
Greatest daily range of temperature		42°, April 23	41°, Jan. 13	42°, Sept. 23	46°, July 7	45°, Aug. 9	46°, July 7, '92.
Least daily range of temperature		2°, January 6	4.5°, *3	4°, Feb. 8	4°, *4	3°, *6	2°, Jan. 6, '89.
Number of clear days		125	109	116	116	96	112.
Number of fair days		103	119	110	123	164	124.
Number of cloudy days		137	137	125	98	105	120.
Number of days rain fell		119	149	119	119	129	127.
Total rainfall	38.25 inches	39.87 inches	54.21 inches	38.36 inches	38.86 inches	40.58 inches	41.69 inches.
Greatest monthly rainfall	4.54 inches	6.73 in. July	7.45 in. October	4.26 in. June	7.89 in. June	6.33 in. Feb	7.89 in June, '92.
Least monthly rainfall	1.39 inches	1.36 in. October	1.74 in. Dec	1.95 in. April	3.37 in. Oct	1.38 in. July	0,37 in. Oct., '92.
Prevailing direction of wind	S.	S.	S.	S	S. W.	S. W.	S.

*1 July 10th, September 1st. *2 February 23d and 21th. *3 January 8th, September 10th. *4 March 5th, November 1st, 3d and 25th, December 1st and 18th. *5 July 7th and 25, September 7th. *6 January 24th, February 11th, May 26th.

Note—The Experiment Station is located one mile south of Wooster, and two miles south of the point at which observations were taken previous to 1893, at about the same elevation. Temperatures were taken in Wooster in 1893.

METEOROLOGY.—TABLE VII.—SUMMARY BY YEARS AND GRAND SUMMARY FOR ELEVEN YEARS.

FOR THE STATE.

	1883.	1884.	1885.	1886.	1887.	1888.
Mean temperature	49.4°	50 6°	48.0°	49.6°	51.4°	49.5°.
Highest temperature	98°, Aug. 22	99.0°, Sept. 28 and Oct. 1	101.0°, July 21	98.6°, July 7	108.0°, July 18	102.0°.
Lowest temperature	—17.2°, Jan. 22	—34.0°, Jan. 25	—31.0°, Jan. 29	—21.5°, Jan. 12	—21.0°, Jan. 7	—15.0°, Jan. 27.
Range of temperature	115.5°	133.0°	132.0°	120.1°	129.0°	117°.
Mean daily range of temp.	19.8°	20.5°	20.4°	20.2°	21.2°	19.6°.
Greatest daily range of temp.	55.2°, March 18	50.0°, Sept 5 and Dec. 4	58.5°, Jan 30	57.0°, Dec. 11	57.0°, April 11	50.0°.
Least daily range of temp.	0.5, Dec. 23	1.1°, Feb. 6	1.0°, April 18 and Dec. 31	1.1°, March 27	1.0°, Jan. 15 and Apr. 16	1.2°, Jan. 16.
Average number of clear days	98.2	116.7	103.5	118.4	113.8	108.7.
Average number of fair days	135.4	118.3	132.8	125 7	127.3	123 4.
Average number cloudy days	130.4	131 1	128.2	121.0	123.9	133.9.
Average number days rain fell.	146.0	145.0	147.7	130 7	120.9	124.7.
Mean yearly rainfall	44.98 inches	40.19 inches	38.08 inches	36.71 inches	33.63 inches	39.64 inches.
Mean daily rainfall	0.123 inch	0.110 inch	0.104 inch	0.100 inch	0.092 inch	0.108 inch.
Prevailing direction of wind	S. W	S. W	S. W	S. W	S. W	S. W.

	1889.	1890.	1891.	1892.	1893.	Summary for 11 years.
Mean temperature	51.1°	52.4°	52°	50°	50.1°	50°.
Highest temperature	99.5°, Aug. 31	103.1°, Aug. 3	101°, Aug. 10	103°, July 25	102°, June 19	108°, July 18, 1887.
Lowest temperature	—13 5°, Feb. 24	—4°, March 7	—5°, March 5	—25°, Jan. 20	—24°	—34°, Jan. 25, 1884.
Range of temperature	113.0°	107.1°	106°	128°	126°	142°.
Mean daily range of temp.	19.3°	19°	20°	19°	21.7°	20.8°.
Greatest daily range of temp.	53.0°, March 30	49.5°, April 11	50°, April 27 and 30	51°, Sept. 25	54.6°	58.5°, Jan. 30, 1885.
Least daily range of temp.	1.0°, Jan. 5	1.0°, Dec. 17	2°*1	1° *2	1°	0.5°, Dec. 23, 1883.
Average number of clear days	112.8	103.4	133	111	122	113.
Average number of fair days	113.8	121.6	109	126	123	123.
Average number cloudy days	138.4	140.3	137	129	120	130.
Average number days rain fell.	114.8	149.4	120	121	113	130.
Mean yearly rainfall	33.53 inches	50.33 inches	38.61 inches	37.16 inches	39.63 inches	39.40 inches.
Mean daily rainfall	0.092 inch	0.138 inch	0.11 inch	0.10 inch	0.11 inch	0.11 inch.
Prevailing direction of wind	S. W	S. W	S. W	S. W	S. W	S. W.

*1 Jan. 4th and 11th. March 19th and 22d. November 12th. December 4th.
*2 July 29th. November 3rd, 12th and 28th. December 17th.

NOTES ON THE WEATHER AT THE STATION.—SUMMARY BY MONTHS.

JANUARY.

The mean temperature was 18°, 9° below the old station average for January. The highest temperature, 51°, occurred on the 28th; the lowest, —9°, on the 11th.

Fair weather prevailed, rain and snow fell on 18 days.

The total precipitation for the month was 4.01 inches, which is .36 inch above the station average for January.

The prevailing wind was southwest.

FEBRUARY.

The mean temperature was 28°, 1° below the station average for February. The highest temperature, 47°, occurred on the 3d, 10th and 15th; the lowest, —2°, on the 20th.

Cloudy weather prevailed. Rain and snow fell on 13 days. The total precipitation for the month was 6.33 inches, which is 1.89 inch above the station average for February.

The prevailing wind was west.

MARCH.

The mean temperature was 38°, which is 9° above the station average for March. The highest temperature, 75°, occurred on the 23d; the lowest, 10°, on the 16th.

Cloudy weather prevailed. Rain and snow fell on 13 days. The total precipitation for the month was 1.89 inches, which is .89 inch below the station average for March.

The prevailing wind was southwest.

APRIL.

The mean temperature was 50.1°, which is 2.9 degrees above the station average for April.

The highest temperature, 83°, occurred on the 7th; the lowest, 24°, on the 15th. Cloudy weather prevailed. Rain and snow fell on 15 days. The total precipitation for the month was 5.66 inches, which is 3.29 inches above the station average for April.

The prevailing wind was southwest.

MAY.

The mean temperature was 57.6°, which is .3° above the station average for May. The highest temperature, 81°, occurred on the 22d, the lowest, 36°, on the 24th.

Cloudy weather prevailed. Rain fell on 13 days. The total rainfall for the month, 6.28 inches, which is 1.77 inches above the station average for May.

The prevailing wind was southwest.

JUNE.

The mean temperature was 69.3°, which is .4° above the station average for June. The highest temperature, 92°, occurred on the 19th; the lowest, 45°, on the 8th. Fair weather prevailed. Rain fell on 11 days.

The total rainfall for the month was 2.51 inches, which is 1.94 inch less than the station average for June.

The prevailing wind was southwest.

JULY.

The mean temperature was 72°, which is 1.2° above the station average for July. The highest temperature, 95°, occurred on the 7th and 25th; the lowest, 47°, on the 4th. Fair weather prevailed. Rain fell on 10 days. The total rainfall for the month was 1.38 inches, which is 2.24 inches below the station average for July.

The prevailing wind was southwest.

AUGUST.

The mean temperature was 67.9°, which is .5° above the station average for August. The highest temperature, 93°, occurred on the 10th; the lowest, 37°, on the 31st. Fair weather prevailed. Rain fell on 5 days. The total rainfall for the month was 1.53 inches, which is 1.02 inch below the station average for August.

The prevailing wind was northwest.

SEPTEMBER.

The mean temperature was 63.2°, which is 1° above the station average for September. The highest temperature, 95°, occurred on the 7th; the lowest, 28°, on the 29th.

Fair weather prevailed. Rain fell on 7 days. The total rainfall for the month was 1.85 inches, which is 1.06 inches, below the station average for September.

The prevailing wind was northwest.

OCTOBER.

The mean temperature was 52.3°, which is 2.7° above the station average for October. The highest temperature, 85°, occurred on the 11th; the lowest, 24°, on the 31st. Clear weather prevailed. Rain fell on 9 days. The total rainfall for the month was 5.15 inches, which is 3.42 inches above the station average for October.

The prevailing wind was south.

NOVEMBER.

The mean temperature was 37.7°, which is 1.3° below the station average for November. The highest temperature, 66°, occurred on the 7th; the lowest, 15°, on the 25th.

Clear weather prevailed. Rain fell on 7 days. The total rainfall for the month was 2.49 inches, which is .61 inch below the station average for November.

The prevailing wind was west.

DECEMBER.

The mean temperature was 30.9°, which is 1.5° below the station average for December. The highest temperature, 62°, occurred on the 25th; the lowest, 6°, on the 10th and 11th. Cloudy weather prevailed. Rain fell on 6 days. The total rainfall for the month was 1.50 inches, which is 1.21 inches below the station average for December.

The prevailing wind was southwest.

INDEX.

(Articles marked * are illustrated.)